THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 60 Thursday, March 30, 1939 No. 1180

PUBLISHED WEEKLY

Subscription Terms : 17s. 6d. per annum.
Foreign and Colonial : 20s. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address : "Zacatecas, Rand, London."
Telephone : Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen

The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

Institute of British Foundrymen

PRESIDENT : 1938-39

J. Hepworth, J.P., M.P., "Ingle Nook," Bolton Road, Bradford.

LIST OF SECRETARIES—

General Secretary : T. Makemson, Saint John Street Chambers, Deansgate, Manchester, 3. London Office : 49, Wellington Street, London, W.C.2.

Birmingham, Coventry and West Midlands : A. A. Timmins, A.I.C., 21-23, St. Paul's Square, Birmingham, 3.

East Midlands : B. Gale, "Parkdale," Boulton Lane, Alvaston, Derby.

Lancashire : J. E. Cooke, 7, Warren Drive, Swinton, Manchester.

London : G. W. Daglish, Stewarts & Lloyds, Limited, Winchester House, Old Broad Street, E.C.2

Middlesbrough : G. P. Kirk, North-Eastern Iron Refining Company, Limited, Stillington, Stockton-on-Tees.

Newcastle-upon-Tyne : C. Lashly, Sir W. G. Armstrong, Whitworth & Company (Ironfounders), Limited, Close Works, Gateshead-on-Tyne.

Scottish : J. Bell, 60, St. Enoch Square, Glasgow.

Sheffield : T. R. Walker, M.A., F.I.C., 11, Broomgrove Crescent, Sheffield, 10.

Wales and Monmouth : J. J. McClelland, 12, Clifton Place, Newport, Mon.

West Riding of Yorkshire : S. W. Wise, 110, Pullan Avenue, Ecclesshill, Bradford.

South Africa : F. C. Williams, Magor House (Fifth Floor), 74, Fox Street, Johannesburg.

Bristol : A. Hares, Park Crescent, 648, Stapleton Road, Bristol, 5.

Burnley : W. Haworth, 37, Westbourne Avenue, Burnley, Lancs.

East Anglian : J. L. Francis, 12, Glenhurst Avenue, Colchester Road, Ipswich.

Falkirk : T. R. Goodwin, "Viewfield," Falkirk Road, Bonnybridge, Scotland.

Lincoln : E. R. Walter, M.Sc., The Technical College, Lincoln.

The Institute of Vitreous Enamellers

President : Sir Harold Hartley, F.R.S., Euston Station, London, W.C.1.

Chairman : W. H. Whittle, W. H. Whittle, Limited, Eccles, near Manchester.

Hon. Secretary : Miss E. Christine Elliot, 49, Wellington Street, Strand, London, W.C.2.

Foundry Trades' Equipment and Supplies Association

President : A. C. Turner, Russell House, Adelphi, London, W.C.2.

Secretary : K. W. Bridges, Grand Buildings, Trafalgar Square, London, W.C.2.

Welsh Engineers' and Founders' Association

President : W. E. Clement, Morfa Foundry, New Dock, Llanelly.

Secretary: J. D. D. Davis, 9, Royal Metal Exchange, Swansea.

BRITISH CAST IRON RESEARCH ASSOCIATION

The Registered Office and Laboratories of the B.C.I.R.A. are :—
21-23, ST. PAUL'S SQUARE, BIRMINGHAM
Telephone : Colmore 4274-4275 *Telegrams : CIRA*
The B.C.I.R.A. Scottish Laboratories are :—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone : 332

Contents

	PAGE
Civil Defence Measures	263
Trends in American Metal Specifications	264
Random Shots	264
Nickel in the Non-Ferrous Foundry	265
Anglo-Indian Trade	266
Pressure-Casting Machine for Cast Iron	267
Pig-Iron Exports	267
Melting Practice in a Large Engineering Iron Foundry	268
The Renfrew Foundries of Babcock & Wilcox, Limited	269
Development in Magnetic Separation	273
Iron and Steel Institute	273
Molybdenum in Cast Iron	274
Book Review	277
Mould Blowing	277
The Week's News in Brief	278
Trade Talk	278
Contracts Open	278
Personal	278
Obituary	278
New Companies	278
French Foundry Technical Association	278
Company Reports	278
Forthcoming Events	278
Raw Material Markets	280

Civil Defence Measures

Details were published last Friday of the new Civil Defence Bill, which Sir John Anderson had introduced in the House of Commons the previous day. It is designed to give as much protection as possible to the civil population against air attack, and involves the Exchequer in an additional direct cost of over £25,000,000, for it excludes the cost of providing free steel shelters and the strengthening of basements estimated to cost £20,000,000. The part of the Bill which affects the foundry industry is that which makes it obligatory for all concerns employing more than 50 people to ensure that every person knows exactly what to do in case of an air raid, and to train a percentage of the employees in first aid, fire-fighting and anti-gas measures. For income tax purposes, the costs incurred which are directly attributable to training and equipment are generally deductible as a trading expense. Those foundries which are located in a vulnerable area, to be specified in an Order, will also have to provide shelters for all their workpeople to give them protection against blast, splinters and falling *débris*.

The Lord Privy Seal is to issue a code which will detail the various types of shelters suited to differences in lay-out in workshops, and also in commercial buildings. A Government grant is to be made to such establishments, which will equal the standard rate of income tax on the capital expenditure on the provision of such shelters. Even those foundries employing less than 50 workpeople, if they be situated in the specified areas, may also receive similar relief, provided the work is effectively started before next September. Provision is made for a similar grant to foundries which, though not located in a vulnerable area, may be regarded as a special target. The administration of this activity is in the hands of the factory inspectorate, but where it refers to commercial buildings, it is delegated to the local authority.

Another phase of the Bill refers to the obscuring of lights, and an onus is placed upon the occupiers of industrial premises to make the necessary provisions. An Exchequer grant not exceeding 50 per cent. will be made towards capital expenditure on structural alterations necessary to obscure the glare from continuous processes, such as blast furnaces, coke ovens and steel furnaces. The camouflaging of industrial establishments may be made compulsory, and again a grant will be made towards capital expenditure. Another important point, which has already caused a certain amount of worry, is the decision that the Exchequer will pay compensation to any persons, whether A.R.P. volunteers or workpeople in industrial or commercial establishments, who receive injuries in time of peace in the course of training or whilst engaged on A.R.P. duties.

It is obvious that in the carrying out of the provisions of the Bill, a considerable amount of goodwill is required on all sides. Already we have heard of disputes as to whether overtime should be payable to men engaged on such work. The proprietor of one concern argued that, as it was primarily for the protection of the workmen themselves, they could please themselves whether they worked overtime or not, but he did not feel justified in paying overtime rates. A problem which requires early attention is the intermediate position occupied by foundries. By "intermediate" we mean that whilst the difficulties of obscuring glare are not so great as those associated with blast furnaces and steel-making furnaces, yet they are by no means so easy as for an engineering works. If a start has been made for casting up a large job, it is difficult to prevent glare arising from empty ladles, cooling furnaces and so forth. During the last war, we found that though current was switched off from large electric furnaces, it was surprisingly difficult to render them glare-proof. Though inconvenience may be experienced, it is well worth while for foundries working on night shift to test out the aspect of their shops consequent on a surprise black-out.

The Bill refers to the differentiation of measures to be taken in various localities and for types of industry. For foundries, it is obvious that much use can be made of sandbags, as the main raw material is always on site and repairs are easily effected. On the other hand, as provisions are to be made for civil defence in all future buildings of major importance, it may be preferable to avoid improvisations and to embark upon a proper workmanlike job that will outlast the rest of the structure. It is profoundly to be hoped that the near future will see the conversion of these shelters into pattern stores for plough points, and that each one of those directing the destinies of nations will realise that the individuals of all nations merely want to be properly clothed, housed and fed and free to pursue their personal interests. Curiously enough, the "technocrats" have created an excess of almost everything, and it is only a matter of unrestricted international trading for this desire to be placed within the ambit of practical politics.

Trends in American Metal Specifications

FOUNDRY PRODUCTS AFFECTED

All the various Committees of the American Society for Testing Materials met in Columbus, Ohio, during the week ended March 11. The following notes refer to the activities of those Committees or Sub-Committees which are concerned with cast metals.

Cast Iron

At the meeting of Committee A-3 on Cast Iron, the sub-committee on wagon wheels presented a progress report, and the group concerned with chilled iron announced that it was conducting an investigation of tension test specimens. The sub-group in charge of work on impact testing plans to submit shortly for study and comment a drawing of a proposed impact testing machine. The newly-formed sub-committee on soil pipe plans to modify the A.S.T.M. specifications for this material to bring them in line with requirements set up by certain committees functioning under the sponsorship of the American Standards Association.

There was discussion of the work on pressure pipe, a sub-committee on this material being in the course of organisation. A decision was taken to carry on the investigation of overstressing of cast iron with irons in the 9.0 and 22 tons per sq. in. classes. Professor Kommers, of the University of Wisconsin, has done similar work on a 15 to 16 ton per sq. in. class iron.

Malleable-Iron Castings

Committee A-7 on Malleable-Iron Castings decided to recommend the adoption as standard of the tentative specifications for cupola malleable iron. These call for a minimum tensile strength of 17.9 tons per sq. in., a minimum yield point of 13.4 tons per sq. in., and an elongation in 2 in. of 5 per cent. Since no suggestions had been received of changes desirable in the standard requirements for castings made by the air-furnace, open-hearth or electric-furnace process (A 47) these are to stand unaltered. Proposed specifications for pearlitic malleable iron were discussed and then approved for a letter ballot vote. There was considerable interest expressed in the work of Sub-Committee VII on Welding, and it was decided to prepare a report on this subject for consideration at the meeting in June at Atlantic City.

Steel Castings

During the meetings of Committee A-1 on Steel, Sub-Committee VIII on Steel Castings recommended the adoption as standard of the specifications covering carbon-steel castings for miscellaneous industrial uses (A 27). Perhaps the most important decision was the approval for submission to Committee A-1 of new specifications for carbon-steel castings for miscellaneous industrial uses suitable for fusion welding. The eight grades of material covered have a maximum carbon content of 0.25 or 0.35 per cent. with the optimum manganese at 0.70 per cent., but with a special provision for an increase in manganese for a reduction below the maximum carbon content. Tensile strengths range from 26.8 to 31.25 tons per sq. in. and yield point from 13.4 to 17.0 tons per sq. in. There has been considerable demand from various interests for standardised requirements for this material, and it is felt that the new specifications, when approved, will be of definite service.

Sand-Cast Copper-Base Alloys

The meeting of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, was a very productive one. During the past year this committee had reorganised its internal sub-committee structure by organising ten sub-divisions, each of which was made responsible for different types of copper and copper-alloy cast, wrought and fabricated products. With the development of new alloys and the increasing use of the materials under the jurisdiction of the committee, it was necessary to enlarge the committee and sub-divide its work.

At the meeting of the sub-committee on copper-base alloys for sand castings, tentative revisions (published last year) of the specifications for manganese-bronze ingots for sand castings (B 7) and for manganese-bronze sand castings (B 54) were recommended for adoption in the specifications this year, and a new revision was approved to provide for the inclusion in these two standards of requirements for a high-tensile manganese-bronze alloy. This sub-committee presented new tentative specifications for nickel-silver casting alloys which will cover four alloy compositions or grades. In order to simplify the preparation of specifications for the many copper-base casting alloys, consideration has been given to the establishment of a classification or appropriate nomenclature for the groups of alloys. This has resulted in the writing of a classification of the cast copper-base alloys for foundry purposes, recommended for publication as tentative this year.

Die-Cast Metals and Alloys

Committee B-6 on Die-Cast Metals and Alloys and several of its sub-committees met. The group in charge of work on tin- and lead-base die-casting alloys is recommending a change in the tin and copper contents of alloy No. 2 in the specifications for lead- and tin-base alloy die-castings (B 102) to provide an increased range of 80 to 84 per cent. tin and 4 to 6 per cent. copper respectively.

Through the co-operation of the Madison-Kipp Corp. the committee has available samples of the five lead- and tin-base alloys. These are to be tested for tensile strength by three laboratories, and creep tests on the specimens will be conducted by two laboratories. The samples will be analysed spectrographically by several co-operating laboratories.

In connection with the work of Sub-Committee IV on Physical Tests of Die-Castings, there was discussion on speed and temperature of tension testing and the length of the impact test-bar. A letter ballot on these matters is being held to elicit the views of various interests.

The Sub-Committee on Exposure and Corrosion Tests has completed tests on all of the zinc alloys on the test racks with the exception of alloy No. 21, and data on these tests will be included in the 1939 annual report. Alloy No. 21, which includes a copper content of 2.5 to 3.5 per cent. and aluminium 3.5 to 4.5 per cent., and the several aluminium alloys included in the tests are to be exposed for at least five years more, so that the total time of exposure will be at least 15 years. These corrosion tests have been under way in various parts of the country, and several reports have been published by the Society.

The committee expects to start exposure tests this year on new zinc and magnesium alloys, tests for physical properties and analyses have been made, and the data submitted to the committee. In the specifications for magnesium-base alloy die-castings (B 94), one new alloy, designated as "13," has been proposed with the following suggested composition:—Aluminium, 8.3 to 9.7 per cent.; manganese, 0.013 min.; zinc, 0.4 to 1.0; silicon, 0.5 max.; copper, 0.05 max.; nickel, 0.03 max.; other (cadmium and tin), 0.3 max.; and balance, magnesium.

Random Shots

With Easter approaching it is to be hoped that the weather will soon begin to think about mending its ways in order to enable those thousands of Britain's foundrymen to overcome a little of that industrial fatigue one hears so much about. Some of them will no doubt try to conquer their industrial fatigue by chasing around the countryside in their new high-speed cars, always intending to stop and gather primroses, but never doing so, because by the time they have been pointed out the car is already half a mile ahead of that particular spot.

* * *

However, if the sun shines sufficiently to allow of picnicking, let everyone remember the rhyme of the untidy man of Nuneaton, which goes as follows:—

A picnicker close by Nuneaton
A part of his meal left uneaten;
The inspector of litter
Said in tones somewhat bitter,
"Get that uneaten Nuneaton bun eaten"!

* * *

Apropos of picnics, here is a good story. One day, Johnnie met two of his school friends just setting out for a picnic. Asking if he could join them, he received the reply that he couldn't, because it was to be an orphans' picnic.

"What's an orphan?" asked Johnnie.

"Why, a boy whose parents are dead, of course," answered his pals.

"Hi, don't go yet! wait for me, I'll be back in a minute," said Johnnie, running down the street as fast as he could.

"It's all right. I can come with you now," he panted, returning soon afterwards.

"What's happened?" asked his astonished pals.

"I've shot my father and I've shot my mother, so now I'm an orphan too! Let's get off!"

* * *

One is so used to hearing after-dinner speeches which begin "My Lords, Ladies and Gentlemen," that one's ears have become deadened to the implied inference that "my lords" are not then to be classed as gentlemen! And on this matter of what constitutes a gentleman there is a variety of opinion. For instance, a maid recently tried to describe her latest young man to her mistress by saying "Oh, he's a gentleman right enough, because he wears spats and works in the City!"

* * *

A local shopkeeper, on the other hand, once discussed a new arrival in the locality with a friend and said "He's a gentleman, he is. He doesn't count his change!" A cynic, nevertheless, once said that a man was surely a gentleman if he used the butter knife and the marmalade spoon even when breakfasting alone.

* * *

Lot IV from the Barrington Hooper Collection.

A gossip is one who talks to you about others; a bore is one who talks to you about himself; and a brilliant conversationalist is one who talks to you about yourself.

"Why did you assault this man?" asked the magistrate.

"Your Worship, I am a pantomime producer and he asked me if I believed in fairies!"

"MARKSMAN."

Nickel in the Non-Ferrous Foundry*

By F. HUDSON

To those interested in the practical side of non-ferrous metallurgy it would seem that there is a distinct tendency to-day for the old order giving place to new. It is now just over twenty years ago since the author first became actively associated with the foundry, first in steel, followed by cast iron, and then the non-ferrous metals, and in looking back over this period he is left with the very firm impression that in

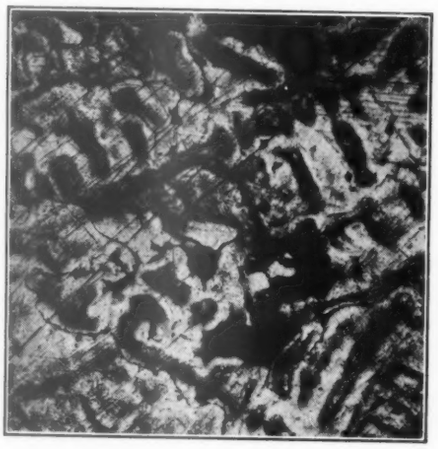

Fig. 1.—Photomicrograph showing Interdendritic Shrinkage Cavities in Bronze due to Effects of Gas Absorption and Inadequate Feeding. × 50.

general, and excluding the phenomenal rise of the light alloy casting industry, the non-ferrous founder has not progressed to nearly the same extent as his brethren in the iron and steel industry. Why? The answer, from a personal point of view, is not far to seek. In the first place everybody is cognisant of the remarkably rapid strides which have taken place in the ferrous industries since the advent of alloy steels

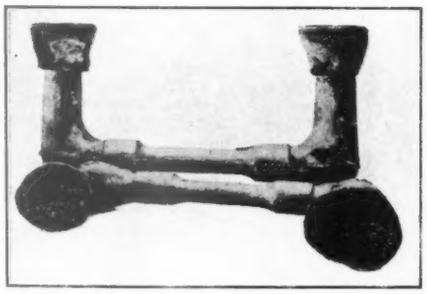

Fig. 2.—Method recommended by I.B.F. for Preparation of Gunmetal and Bronze Test Bars. This method, whilst fairly satisfactory from the practical viewpoint, does not ensure even feeding along the length of the bar.

and cast irons. This has resulted not only in an improved product of greater interest to the user, but a product having greater interest to the founder himself. Consider for a moment the case of alloy cast iron. Its inception called for increased technical control and the installation of more efficient practical methods of production. These factors alone have undoubtedly improved the prestige of the ironfounder, but a point of still greater importance has resulted from the active interest shown by the workers in this field in outlining developments and airing their problems through the medium of the Press and technical institutions. Furthermore, it is interesting to note that most of this latter work has not directly evolved from the truly practical man, but has been contributed by the more technical worker.

Under the circumstances it is suggested that in order to increase the prestige of the non-ferrous casting industry as a whole, it would not be inopportune to take a leaf from the ironfounder's notebook and consider the practical development of newer and more modern alloys. Improved technical control would be a natural sequence, and this in turn would provide an outlet for a much greater sphere of practical non-ferrous activities in the type of technical institutions to whom this Paper is read. In the opening remarks reference was made to the present tendency for the old order giving place to new. This was prompted by the fact that, as in the case of cast iron, alloy additions to non-ferrous metals are becoming more and more important. Nickel, chromium and beryllium, together with other alloys, are playing increasingly important rôles in the production of high-duty non-ferrous castings, and one might see therein the first signs of a new era of development.

In keeping with these remarks, it is accordingly not proposed to deal with old-established methods in this Paper, but rather to outline foundry practice relative to the more recent advances in non-ferrous metallurgy as applied to a typical modern alloy. The alloy selected for this purpose is the latest high-duty bronze containing 5 per cent. nickel, 5 per cent. tin, 2 per cent. zinc, balance copper.

Nickeliferous Gunmetals

The simplest conception of this alloy is Admiralty gunmetal in which the composition has been modified by replacing 5 per cent. of tin with nickel, and it is of considerable interest to the non-ferrous foundryman inasmuch as it is susceptible to heat-treatment, permitting castings to be readily produced having mechanical properties similar to high-tensile brass.

Table I.—*Physical Properties of* 88-5-5-2 *Bronze "As Cast" and after Heat Treatment.*

	As cast.	Heat treated.
Max. stress, tons/sq. in.	21.6	31.2 to 40.2
Yield point, tons/sq. in.	10.9	22.3 to 33.0
Elongation per cent. on 2 in.	42.0	25.0 to 5.0
Brinell hardness No. ..	86	140 to 200

So far as composition is concerned the alloy is by no means new. In 1923 a British Patent,[1] now expired, was granted to a German firm putting forward the cast material as being very suitable for use with superheated steam up to 500 deg. C. It was also pointed out that at this time the standard tin bronzes were not easily manufactured into rolled or drawn products, but the material modified with nickel could be readily fabricated into wire having a tensile strength varying between 28.5 and 66.5 tons per sq. in. Such wire was particularly suitable for Foudrinier or paper machine wires, as it had been proved to be still serviceable after a period of use twice as long as that obtained from the best wires previous available.

It was not until 1931 that the possibility of improving the mechanical properties of the alloy by heat-treatment was discovered in the United States by Wise.[2] This development has since been fully outlined by Wise and Eash[3] in a Paper given in 1934, and more recently by Kihlgren[4] this year. Briefly speaking, it has been found that a bronze containing 5 per cent. nickel, 5 per cent. tin, 2 per cent. zinc, when melted and cast with good foundry technique has mechanical properties, before and after heat treatment, as shown by Table I.

It will be observed that "as cast" the alloy yields properties somewhat superior to those normally obtained from Admiralty gunmetal, and these are increased to useful limits by suitable heat-treatment.

So far as the production of castings is concerned this material presents no serious difficulties, and the practice common to the ordinary bronze alloys can be employed quite satisfactorily. If the best results, however, are required, particularly after heat-treatment, certain apparent

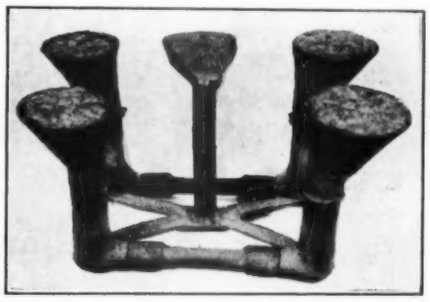

Fig. 3.—Modified Method of Running I.B.F. Bar to ensure Even Feeding Action and More Consistent Results.

modifications in foundry technique are desirable. The word apparent has been employed in this instance in view of the fact that the modifications entailed are not so much peculiar to the alloy at the moment under discussion, but typically illustrative of the practical application

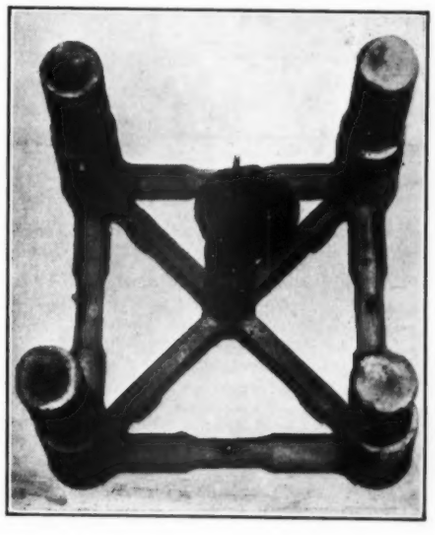

Fig. 4.—Eash-pattern Test Bar as employed in U.S.A., and found to give excellent results with 5 per cent. nickel bronze, nickel silver and Monel.

of the more advanced metallurgical discoveries to the production of sounder non-ferrous castings as a whole.

In order to develop maximum quality in castings it is in the first place essential that they should be perfectly free from such defects as porosity and interdendritic shrinkage as shown

* A Paper read to a joint meeting of the London Branches of the Institute of British Foundrymen and the Institute of Metals, Mr. Barrington Hooper presiding. Also read to the Scottish Branch of the Institute of British Foundrymen, Mr. R. Ballantine presiding.

by Fig. 1. Whilst a small amount of this defect is not uncommon in the average commercial article, its presence is fatal to alloys which must exhibit the highest possible physical properties. This point is of interest in connection with bronzes of the present type, which must be subsequently heat-treated, as it prevents the maximum properties being obtained, particularly so far as elongation is concerned. The occurrence of interdendritic shrinkage in non-ferrous castings can usually be ascribed to three common factors:—

(1) Unsuitable placing of gates and risers.
(2) Incorrect pouring temperature.
(3) Gas absorption due to improper melting or deoxidation methods.

In addition to the above, there is, of course, the question of design and composition, but as

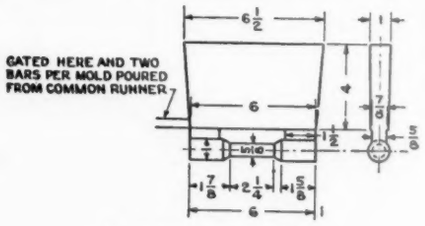

Fig. 5.—Pattern 10*a*.

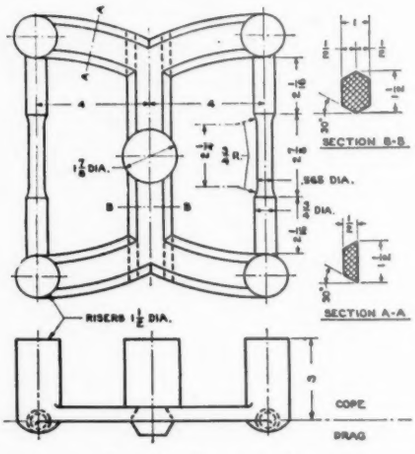

Fig. 6.—Pattern 11*a*.

these vary over such wide limits they are considered outside the scope of this present Paper.

Unsuitable Placing of Gates

The subject of gates and risers is always of interest to the practical man, and their correct use is of primary importance in obtaining castings of maximum strength and density. It is, however, a subject upon which surprisingly little has been written. Consider, for example, one of the simplest yet most important castings that the non-ferrous founder has to produce—the tensile test bar. What is the best method of moulding? The particular type of alloy being handled will, of course, have a considerable bearing upon this matter, but so far as the bronzes are concerned there is at the present time still considerable scope for improvement.

In 1936[5] the Non-Ferrous Sub-Committee of the Technical Committee of the Institute of British Foundrymen published a report covering "Recommendations for Two Leaded Gunmetals" advising the method of preparing test bars as shown in Fig. 2. This was a step in the right direction, and permits fairly satisfactory results to be obtained. It has been found, however, that this method is open to two objections. In the first place, there is a distinct tendency for the finished-machined test-piece to break at the shoulder when being pulled at loads below those normal to the material. Investigation has indicated that in the majority of cases where failure has occurred outside the gauge length, there has existed a drop in density and a difference in mechanical properties between the metal at the shoulder and that in the centre of the bar. Furthermore, it has also been substantiated that failure invariably occurs at the end of the bar farthest away from the ingate, *i.e.*, at the riser end, where the metal is coldest. This difference becomes naturally more pronounced as the length of the test bar increases. This factor has given rise to considerable trouble being experienced in regard to non-ferrous research investigations requiring strictly comparable data producing erratic results and consequent inability to draw conclusions.

The variation in properties exhibited by the I.B.F. bar seems to be due to slight interdendritic shrinkage caused by unequal feeding action brought about by the difference in temperature between the metal in the runner and that in the riser. In order to obtain maximum density, those parts of a casting last to solidify should be supplied with hotter metal from a

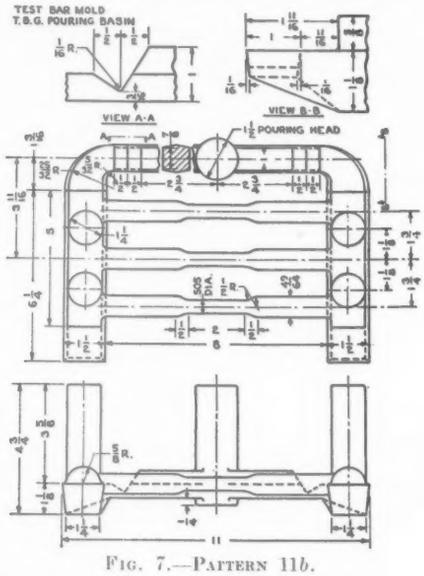

Fig. 7.—Pattern 11*b*.

Figs. 5, 6 and 7.—Recommended Methods of Test-Bar Preparation put forward by U.S.A. Federal Government (Patterns 10*a*, 11*a* and 11*b*). All these designs confirm the desirability of pouring both ends of the bar at the same time in conjunction with choke gates and ample risers. The short pattern bar 10*a* appears useful for alloys with high liquid shrinkage.

riser, so that positive feeding can be assured. With this design the metal in the riser is, if anything, colder than that in the adjacent section of the bar, and accordingly even and adequate feeding is not obtained. It is interesting to note that this type of bar is unsuitable for use with the 5 per cent. nickel bronzes in the heat-treated condition, as it gives low elongation-values due to the presence of the above mentioned interdendritic shrinkage. The obvious remedy is, of course, to reverse the thermal difference by pouring both ends of the test piece at the same time by adopting the method illustrated in Fig. 3.

This modification to the I.B.F. bar enables more consistent results to be obtained, and has the additional advantage that choke gates can be employed which tend to produce cleaner castings. From the theoretical point of view, one cannot understand why non-ferrous castings should be so often poured through large runners of such size that it is impossible to keep the runner basin full. No doubt this originated from the accepted fact that a well-proportioned runner gives better feeding action than a riser. At the same time, it seems illogical to continue the use of a method which readily permits slag, etc., to enter the mould with the metal stream when more efficient alternatives are available.

The use of choke gates attached to adequate feeding risers should, on the whole, permit better non-ferrous castings being obtained, and they are essential for the handling of special alloys (such as those containing nickel) which form surface oxide films when molten or when slags or fluxes are being employed during the melting operation. In pouring the test piece from both ends, it might be anticipated that trouble could arise through the presence of defects at the meeting place of the two metal streams in the middle of the bar. This is, however, not experienced in actual practice, and the method has been very successfully employed even for relatively high melting-point metals, such as Monel. It is advisable to vent the top part of the mould thoroughly or, alternatively, place a "whistler" at the middle of the bar to release air.

In the United States, the preparation of test bars has been well studied, and Fig. 4 shows the Eash pattern, which has been found to give excellent results with the heat-treatable 5 per cent. nickel bronzes as well as nickel-silver and Monel. The "whistlers" or vents previously mentioned at the centre of the bars should be observed. In view of what has already been mentioned, this design will obviously give consistent results when employed for ordinary gunmetal and bronze. It should also be noted that in America recommended methods of gating test-bars are actually outlined in Federal Government Specifications as illustrated in Figs. 5, 6 and 7. All these designs confirm the desirability of uniform and positive feeding action obtained by pouring both ends of the test bar at the same time in conjunction with choke gates and ample risers. The short pattern test-bar shown in Fig. 5 appears useful for alloys having high liquid-shrinkage.

(To be concluded.)

REFERENCES.

1 Brit. Pat. 186,336.
2 U.S. Pats. 1,816,509 and 1,928,747.
3 E. M. Wise, J. T. Eash. "Strength and Ageing Characteristics of the Nickel Bronzes." Trans. Amer. Inst. Min. Met. Eng. (Inst. Met. Div.), 1934, Vol. CXI, pp. 218–244.
4 T. E. Kihlgren. "Production and Properties of Age-Hardenable Five per cent. Nickel Bronze Castings." Trans. Amer. Foundrymen's Assocn., 1938, Vol. XLVI, pp. 41–59.
5 Inst. British Foundrymen, "Recommendations for Two Leaded Gunmetals." Proc. Inst. Brit. Foundrymen. 1935–36 Vol. XXIX, pp. 349–359.

Anglo-Indian Trade

Announcement of the main provisions of the Anglo-Indian trade agreement shows that it guarantees a number of preferences to British goods, including iron and steel. The new agreement follows the termination of the Ottawa Agreement of 1932, notice of which was given by the Government of India in May, 1936. The new trade agreement will come into formal operation as soon as the legislative measures have been passed. Meanwhile the two Governments have undertaken to give effect to its provisions as far as possible.

It is anticipated that the Government of India will bring into effect at the beginning of April reduced rates of duty on United Kingdom cotton piece goods, and will revise the Ottawa preferences on other United Kingdom goods. The preferences accorded under the agreement cover a value of United Kingdom trade which is estimated on the basis of 1937-38 figures at about Rs. 900 lakhs (£6.7 million). The Ottawa preferences which are not being continued by India under the new agreement cover a value of United Kingdom trade which is estimated on the same basis at about Rs. 1,000 lakhs (£7½ million).

The following are among the most valuable items on which preferences are guaranteed in each case with a margin of 10 per cent. *ad valorem*: Electrical instruments, apparatus and appliances; iron and steel hoops and strip, and barbed or stranded wire and wire rope; copper wrought, and manufactures of copper.

The following are among items on which the preferences (10 per cent. *ad valorem*) accorded under the Ottawa Agreement are being discontinued:—Hardware, ironmongery and tools; iron and steel pipes and tubes.

Pressure-Casting Machine for Cast Iron

The latest issue of *La Fonte* to arrive in London contains a description of a machine for pressure-casting cast iron which was inspected by a representative of that journal. The machine was designed by Mr. J. de Sternberg, and Mr. J. Floquet is the licensee.

The apparatus embraces a number of particularly ingenious devices, which have solved, on an industrial scale, the major problems connected with the pressure-casting of iron. Figs. 1 to 3 show schematically the functioning of the Sternberg machine. In practice, the layout is a little different in order to adapt itself to the various types of castings to be made, as well as to the exactions imposed by the handling of liquid metal.

The pressure box is shown in Fig. 1. This box is made from a block of steel *a*, to which is fitted, on the lower side, a crucible *b* for carrying a small quantity of liquid metal. It is electrically heated by the resistance coils *c* and insulated by *d*. The lower part of the crucible is formed by a metal piston *e*, capable of freely moving in the crucible *b* and in the pressure box *a*. The joint between the piston and the crucible is made by a plug *f* formed from compressed steel-wool and asbestos cakes. This part of the machine works as follows:—The piston being set in the lower position, the crucible receives the charge of liquid metal; the latter can remain for some little time in the apparatus, the temperature being maintained constant by regulating the heating.

For casting, the piston *e* is raised and the iron passes into the central cavity of the metal pressure box *a*. It is only when the piston has reached the lower part of the pressure box that pressure begins to be imposed upon the mould. Thus at no moment is pressure placed upon the working table *b*. This table embodies an opening *c* on which the mould-carrier *d* is placed. The arrangement of the crucible and pressure box detailed in Fig. 1 is shown diagrammatically in Fig. 2 at *e*. This assembly is mounted on a mobile carrier *f* which permits of the introduction of the pressure box *e* into the inside of the compartment *a*, through the opening *g*, the latter being closed by the plate *h*. The pressure box is pushed by means of the action of the lever *i*, which brings it flat against the mould. The crucible which has been filled with metal, which up to now has been on the exterior of the machine, is pushed inside as just shown above.

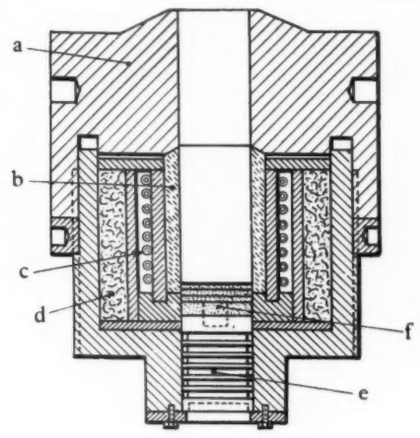

Fig. 1.

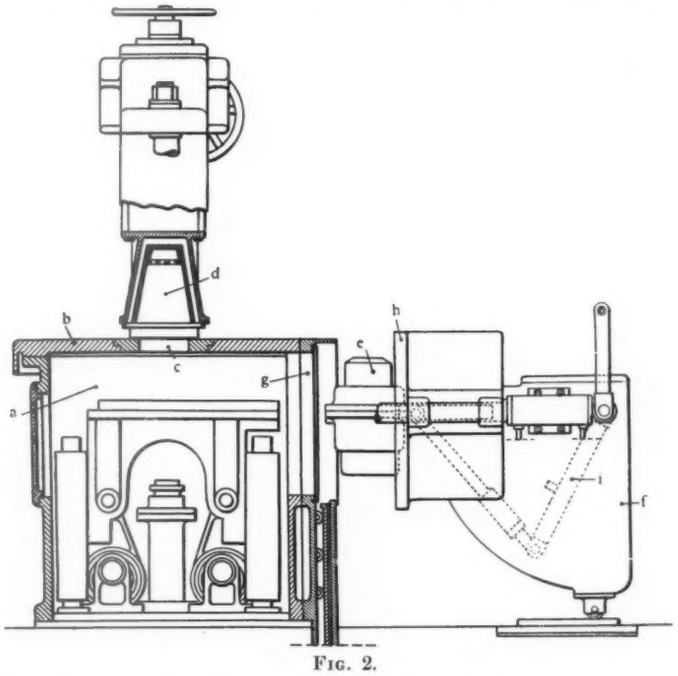

Fig. 2.

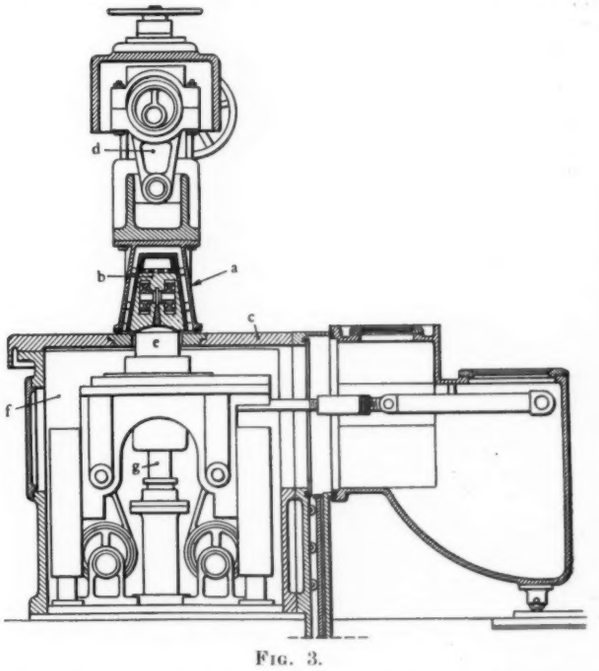

Fig. 3.

walls of the crucible, which is solely for the purpose of providing a refractory receiver. Moreover, the time for which the pressure box *a* is exposed to the action of the liquid metal is of extremely short duration. This at the same time limits the chilling of the iron and the deformation of the walls of the box by contact with the liquid iron.

The general construction of the machine is shown in Figs. 2 and 3. In Fig. 2 is shown the framework of the machine made up from a sealed compartment *a* terminating at the top by the

The sequence of operations is best shown by reference to Fig. 3. The mould-carrier *a*, in which has been placed a mould *b*, is lowered to contact with the work table *c* by means of a cam action *d*, which ensures that a light contact is made between the mould and the table.

A similar action ensures the contact of the lower face of the mould *b* and the pressure box and crucible assembly *e* which is introduced into the sealed compartment *f* as explained above.

As soon as the sealed compartment is air-evacuated, as also is the mould which communicates with it, pressure is applied by means of the piston *g* (actuated by a system of cranks not shown in the sketch) which allows the obtaining at the end of the stroke of a very considerable pressure, which may reach something of the order of 5 tons per sq. cm.

These various operations take place very rapidly, so that the contacts between the iron and the various metallic parts of the machine and mould are of very short duration. During all idle time, the iron remains in the crucible, where a suitable casting temperature is maintained, without affecting the essential mechanical parts of the apparatus.

The castings obtained from this machine show extremely smooth surfaces. They can be made in relatively thin sections and the metal can be injected through apertures of very small sections.

It should be understood that all irons of normal composition will carry a white structure under such conditions, and it is necessary to submit them to a graphitisation treatment where machining is envisaged or where service conditions require a non-fragile material and where freedom from stress is important.

Pig-Iron Exports

A Middlesbrough firm of merchant exporters has written a letter to the Comptroller General of the Department of Overseas Trade pointing out some of the unfair handicaps imposed upon British pig-iron exporters. In the course of this communication the writers state: "In view of the fact that currency restrictions in many countries abroad have brought our exports more or less to a standstill, it is imperative that conditions in connection with other countries should be tightened up so that we get full advantage of our enormous imports." Citing the case of Denmark, the writers state: "For many years past Denmark has been a very good customer for English pig-iron and particularly pig-iron from the Middlesbrough district, both foundry and hematite qualities. At the present time, however, owing to the very low prices prevailing on the Continent, Denmark is able to obtain her supplies elsewhere to the detriment of this country. Holland is now exporting considerable quantities of pig-iron to Denmark, which is rather one-sided, as Holland, being an agricultural country, like Denmark, is not able in return to accept delivery of Danish produce. Surely, therefore, as the largest importing country in the world, this should not be allowed to continue, especially at a time when our export trade is at a very low ebb and sadly in need of all the advantages of an adjustment of the trade balance."

Melting Practice in a Large Engineering Iron Foundry

DISCUSSION OF MR. W. W. BRAIDWOOD'S PAPER

The discussion of Mr. W. W. Braidwood's Paper on "Melting Practice in a Large Engineering Iron Foundry," following its presentation to the Scottish Branch of the Institute of British Foundrymen, was productive of additional information on various aspects of the subject: The Paper was reproduced in the March 16 and 23 issues of the JOURNAL.

DISCUSSION

The CHAIRMAN (Mr. R. Ballantine), in opening the discussion, said he had never previously listened to a Paper with such a wealth of detail. He was particularly interested in the design of the interior of the cupola, but he regretted Mr. Braidwood did not mention blast volume. He would also like to know whether the author had made any thermal tests of the drum ladle.

MR. BRAIDWOOD, in reply, said that the fans in use supplied air at a constant pressure, the volume passing into the cupola being dependent mainly on the permeability of the furnace contents. The volume meters mentioned were not used to ensure a constant and predetermined input of air, except during "blowing-down." It might be stated that the normal input was 3,500 cub. ft. of free air per minute. Metal temperatures were read by means of a Siemens' optical pyrometer. The procedure was useful in providing readings which were of value for control purposes, but comparative only on their own scale. He hesitated to quote these readings because he felt that they were much below the true temperatures, and, if taken literally, would give the impression that the metal temperatures were low. He remarked, jocularly, that in the present instance it might be best to make use of the empirical scale established by a member of the Branch, and state that the temperatures of the metal tapped from the cupola under discussion ranged from "hot" to—well—"very hot." No thermal determinations had been carried out on the drum ladle, principally because the improved results associated with its use were very obvious.

Furnace Contour

MR. JOHN CAMERON, JNR., congratulated Mr. Braidwood on his excellent Paper, but he also questioned the internal design of the cupola. He wondered whether the shape was exaggerated in the drawing which had been shown, and if the melting zone were above the narrow throat. If so, he thought it was too far away from the main tuyeres. He would like to know if Mr. Braidwood was making castings to all the British Standard specifications.

MR. BRAIDWOOD explained that the present contour had been evolved gradually, and that improved results had been found to be associated with the development. No scaffolding had ever been experienced, and he agreed that this undoubtedly was due to the fact that melting occurred above the narrowed section. Regarding the coke bed, he wished further to emphasise his conviction that the deep bed maintained in the operation of these cupolas was the most potent single factor influencing their performance. The metal produced was meeting a tensile test of 20 tons per sq. in. on the 1.2-in. dia. bar.

Tuyere Systems and Carbon Control

MR. LONGDEN said he found the Paper very interesting and of considerable value, but he wanted more light on details. Did Mr. Braidwood use high total carbon? He (Mr. Longden) had tried to get low total carbon in a Poumay cupola, but found it impossible. He also considered that auxiliary tuyeres did not give hotter metal; at least he had not found that to be the case with the Poumay cupola. It might be that the receiver made a difference, but he thought that the argument in favour of the receiver could be overstated. He would like to know whether the receiver made for "clean" metal. The open slag hole, he said, had some advantages, and gave a good datum line of the progress in the cupola. He thought the best test of the performance of a cupola was the analysis of the gases, the temperature of the metal and the metal/coke ratio.

MR. BRAIDWOOD said that in his high-duty cast irons the total carbon contents varied generally between 2.8 and 3.0 per cent., and were certainly never higher than 3.2 per cent. He used from 25 to 60 per cent. of mild steel scrap in these charges. He had never operated a Poumay cupola; but since, in that type of furnace, the secondary air was introduced at intervals up to a considerable height above the bed, and therefore into relatively cool regions, he expected it to give very efficient combustion. He had found, however, that improved gas analysis was not necessarily accompanied by increased metal temperatures; this he believed to be influenced primarily by the depth and condition of the bed.

On the subject of receivers generally, Mr. Braidwood said that he did not advocate the fitting of a receiver to every cupola. Where comparatively small amounts of metal were being melted, for example, the use of a receiver was hardly justifiable, unless required for special purposes. He had tried to show, however, that the hot-metal receiver could be an extremely useful component possessed of advantages greater than was generally realised.

MR. W. Y. BUCHANAN complimented the lecturer on his presentation of the Paper, especially on the remarkably good drawings, which were a credit to the artist. He had seen the lay-out of the cupola plant, and it was undoubtedly good. He was especially interested in the balanced-blast cupolas, as members of the Babcock & Wilcox staff had studied his own firm's cupolas and melting control system before planning their installation, and as the cupolas described were of similar dimensions, comparison of performance was possible and of particular interest to himself.

The only part of the lecture which he could not accept was the exaggerated shape of the lining. The bosh was present in all balanced-blast cupolas to the extent of 2 in. or so a side, but why increase it to 15 in. a side, thus reducing the area to less than one-third for the same blast input? What was wrong with these furnaces that such a radical alteration was necessary or advisable? It was an old style of lining which was, he thought, obsolete. He thought it was bound to come in for considerable criticism.

He suggested that coke saving could be had by reducing the depth of the bed below the tuyeres to a few inches, say as low as 3 in., if coke saving was important; but the method suggested must be at the expense of the quality of the metal, probably making the tuyere zone cold. Mr. Braidwood's figure of 0.8 per cent. loss for the balanced-blast operation, due to oxidation and slag, etc., confirmed his own practice.

Temperatures on different optical instruments were sometimes uncertain for comparison, but statements that the metal was "hot" or "very hot" were, of course, quite useless in technical literature. He concluded that the temperature of the metal was much lower than usually used. The temperature indicated by, say, the average of several thousand readings before and after the lining modification, taken on the same pyrometer by the same man, would have given a reliable guide on this question.

Mr. Braidwood had raised the stock line of the furnace by 3 ft., he understood, in order to cool the exit gases. His own experience was that above the normal height this might defeat the object which was intended, and by slowing the furnace, produce colder metal at the spout.

The author had made out a strong case for receivers on the grounds of reduced heat losses, but his data on temperature did not bring this out clearly.

Mr. Buchanan also asked for the extra cost of lining the furnace so heavily at the lower part. His own ganister to metal was about 1 to 75, which seemed quite as good for melting every day with the consequent lack of drying time. Finally, he would like to know how much metal was rejected daily as being unfit for casting.

Metal Temperatures

MR. BRAIDWOOD said that he had fully expected the matter of the furnace contour to be controversial. It was surprising, however, and somewhat disappointing, to hear it described as "an old style" and "obsolete," when he had regarded it as extremely new—indeed, as his own invention. There had been nothing "wrong" with the cupola before the alteration of contour, but the change had been associated with considerable improvement in the cupola performance. He recommended Mr. Buchanan to try out this contour. It was difficult to estimate the cost of lining-in to the diameter shown; in the existing case this had been effected by regular decrease of the diameter when patching.

Mr. Buchanan had suggested saving coke by reducing the height between the sand bottom and the main tuyeres. At present this dimension was only 12 in., and he did not think that any reduction was advisable, especially since this alteration, by reducing the depth of incandescent coke, would tend to lower the temperature of the tapped metal. Mr. Buchanan had misinterpreted his information about the overall dimensions of the cupola. The height from main tuyeres to stock line (14 ft. 6 in.) was the same as before the alteration in contour.

He was glad to have confirmation, from Mr. Buchanan's own experience, of the figures quoted for oxidation loss. He felt that their publication would be of interest, especially since it was thought by many that operation of the balanced-blast system must give rise to high oxidation losses.

He could not allow Mr. Buchanan to observe that the temperature of the metal tapped was other than very satisfactorily hot. The actual readings made at the spout varied from 1,300 to 1,350 deg. C., but these figures should not be accepted as correct temperatures. He remembered one occasion when Mr. Marshall, of Thomas White & Sons, Limited, visited the foundry and commented on the high temperature of the metal being tapped, estimating it as "well over 1,400 deg. C." The actual reading which had just been observed and recorded on that occasion was in the region of 1,320 deg. C.

MR. MARSHALL: That is the case.

Continuing, MR. BRAIDWOOD said the query regarding the weight of metal rejected daily as being unfit for casting might best be answered by quoting the official returns for the year ended December 31, 1938. These showed that, with a total metal weight of 30,166 tons, the total weight of castings produced was 21,931 tons, or over 70 per cent. of the total melt. This might modestly be described as representing very good practice, and these figures certainly did nothing to encourage the belief that a considerable proportion of the melt was unfit for casting.

After further discussion, MR. A. L. MORTIMER moved a hearty vote of thanks to the lecturer.

MR. BRAIDWOOD, in returning thanks, mentioned that this was his maiden "opus," and said that he had been rather worried regarding its presentation. Fortunately, he had thoroughly enjoyed the experience.

The Renfrew Foundries of Babcock & Wilcox, Limited

Introduction

Few foundries in Europe present so many interesting aspects as those embodied within the organisation of the Renfrew works of Babcock & Wilcox, Limited—the largest manufacturers of boiler plant in the world. This is because the requirements are such that, whilst an opportunity is afforded for quantity-production of such parts as stoker links, there still remain plenty of one-off jobs demanding the individual attention of the craftsman. Moreover, the basis of production is extremely wide, as it also embraces malleable iron and steel. Non-ferrous castings are made at a separate works located at Dumbarton.

The works are particularly well managed, and the shops are light, extremely tidy and (what is more important) virtually free from dust. The choice of equipment is particularly catholic, and products of practically every manufacturer are to be found in one department or another.

The works' output is mainly for export, and during the slump the management kept the shops reasonably well employed without receiving a single order from the public utility authorities for a plant of major dimensions. The firm is the type of concern which creates considerable credits abroad for the purchase of food imports, and as such ranks amongst the most important keystones of the British industrial structure.

STEEL FOUNDRY

The general layout of the steel foundry is shown in Fig. 1, and its general appearance is illustrated in Fig. 2. This photograph has been taken from the electric-furnace stage looking towards the annealing stove. The shop is 350 ft. long and 75 ft. wide, but about half way down there is a second bay 35 ft. wide. Externally, transport is effected by a jib crane, beneath which are a length of sidings, storage bins and the electric-furnace charging platform. Internally the transport system consists of four Babcock & Wilcox overhead electric travelling cranes of 10 tons, two of 5 tons, and one of 2 tons capacity, supplemented by floor bogie tracks. Additionally, there are five 30-cwt. hydraulic jib cranes for servicing the moulding machines, the shot-blast plant and the dressing floor. The 2-ton overhead crane is erected in the smaller bay.

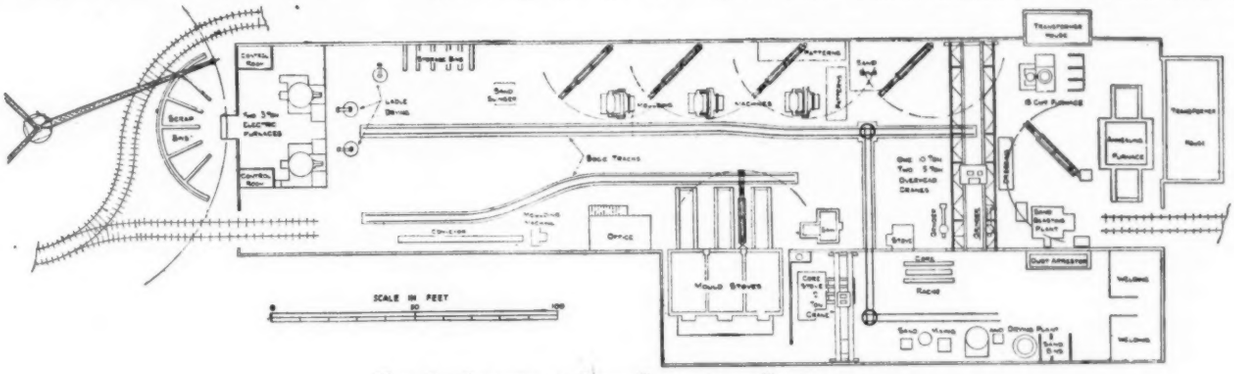

Fig. 1.—Lay-out of Steel Foundry at Renfrew.

Melting Plant

Melting is effected in two locations in the shop. The two Héroult furnaces installed at the end of the shop are of Siemens-Schuckert design and manufacture. They are of 3 tons capacity, and their general appearance is shown in Fig. 3. These furnaces, which are automatically controlled, utilise good, clean scrap from the forge and tube mill, and melt a heat in about 2½ hrs. The third furnace, also automatically controlled by Watford apparatus, is a standard 15-cwt. Héroult furnace made by the Electric Furnace Company, Limited, and turns out heats of alloyed steel in 2 hrs.

Sand Preparation

For dry-sand work a synthetic sand is prepared in a Pneulec mill (Fig. 4) of 2½ tons per hr. capacity. For green-sand work, there is a disintegrator and an electric riddle, while a Pneulec Royer machine reconditions the backing sand. For the preparation of the oil-core sands there is a Rotoil mixer. In the control of the sands, a strict specification is imposed as to moisture content and grain size. This service is undertaken by the foundry sand laboratory, and should fundamental knowledge be required, recourse is had to the research laboratory.

Moulding

The foundry is extremely well equipped with machinery for moulding, though, of course, there is still a fair amount of hand work carried out, the variety of work undertaken being very wide. There are three Pneulec Herman jolt-ram turnover moulding machines of 4,000-lbs. capacity. These make each day something of the order of 15 moulds, ranging from 2 ft. to 4 ft. square, for castings weighing from 5 cwts. to a ton.

In addition there is a stationary Sandslinger for handling both light and heavy work. For quite light work there is a jar-squeeze turnover, type W1, supplied by W. J. Molyneux, of Wolverhampton. This machine is serviced by a

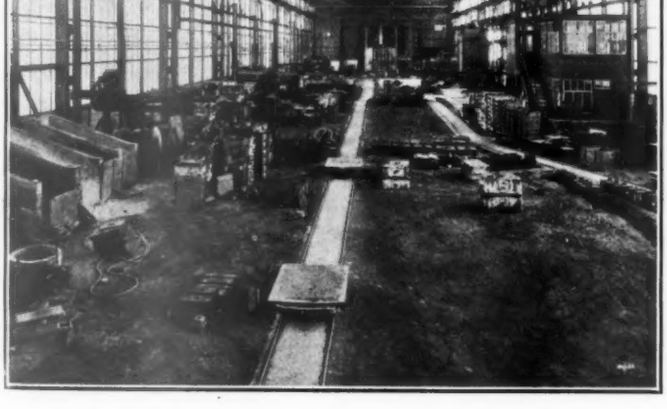

Fig. 2.—View of Steel Foundry from Furnace Stage.

Fig. 3.—Steel-melting Plant and Ladle Drying Lay-out.

length of roller track for the rapid disposal of the moulds made.

Most of the heavier moulds are made in dry sand, and there is a battery of three Pneulec stoves, placed conveniently near the large moulding machines. They are coke-fired, using forced draft, and are pyrometrically controlled, a record of each drying operation being graphed.

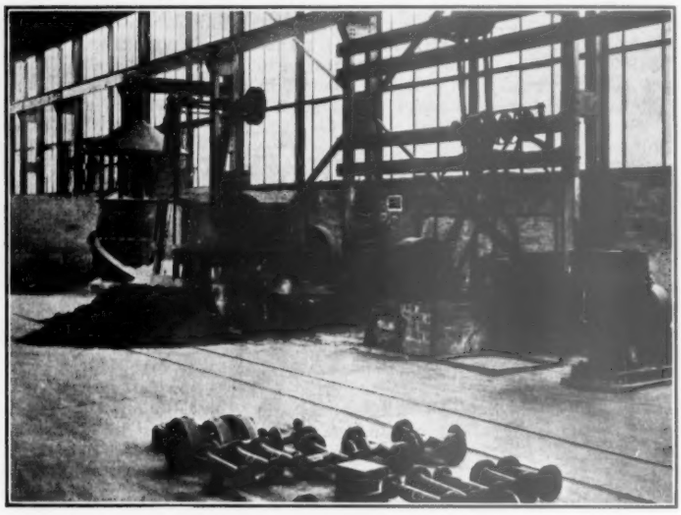

Fig. 4.—Sand-Preparing Plant for Steel Foundry.

Core Making

The core-making department is housed in the smaller bay. Cores are made in small Pneulec jar rammers and by hand. The smaller ones are conveyed to and dried in an Acme continuous stove, whilst the larger cores are dealt with by a forced-draft bogie-type stove. The moulds are closed in an area adjacent to the furnaces, and are cast from bottom-pouring ladles. There is a special oil-fired plant for drying out and heating up the ladles.

Fig. 5.—Saw for Removing Risers.

Fettling

The moulds are not knocked out on site, but are taken to a central knock-out station, where they are roughly freed from sand and cores. They are then taken to the saw shown in Fig. 5, where the runners and risers are cut off without undue liberation of heat. This method is preferred by the management to gas cutting; moreover, subsequent machining operations are facilitated. This saw is made by Gustav Wagner of Germany. The castings are then transported to a high-pressure shot-blast plant (Fig. 6) supplied by St. George's Engineers, Limited, of Manchester. For final dressing recourse is had to some well-designed swing grinders and ordinary double-ended stationary machines. Extensive use is also made of pneumatic chisels.

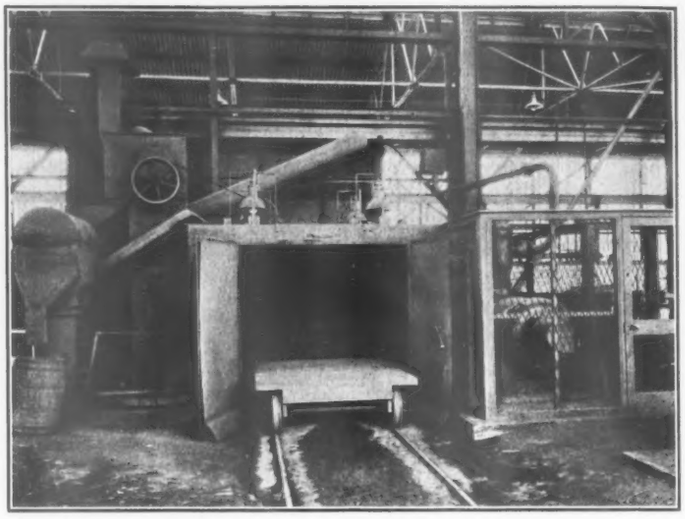

Fig. 6.—High-Pressure Shot-Blast Plant.

Heat-Treatment

An excellent plant has been installed for the heat-treatment of the steel castings. It is oil fired and controlled pyrometrically. The removable hearth is shifted by the overhead crane through a snatch-block set in the floor of the foundry. The plant is illustrated in Fig. 7.

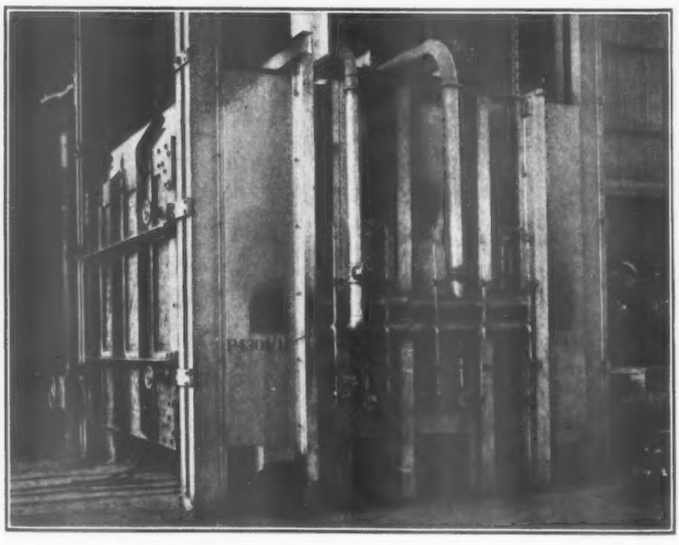

Fig. 7.—Heat-Treatment Plant for Steel Castings.

General

Though this foundry was only completed last year, it has a background of twenty years' experience. It not only makes the requirements of the engineering department, but also undertakes general work for the trade. As will be realised from the above description, its very elastic equipment places it in a splendid position to undertake either a one-off job or repetition lines within a finished weight range of well over a ton. The department employs 110 men, and the current annual production is of the order of 1,000 tons of plain carbon and 150 tons of alloyed steel castings. Into the latter category enters a nickel-chrome steel sold under the trade name of "Calmet."

IRON FOUNDRY

Our readers are already familiar with the general layout and melting practice at the Renfrew iron foundry, as these were dealt with in full detail by Mr. W. W. Braidwood in our last two issues. Readers are referred to the plan of the iron foundry on page 232 of the March 16 issue, from which it will be seen that the foundry consists of four bays 512 ft. long with an overall width of 256 ft. The first bay is confined to green sand, and extensive use is made of the Tractor Sandslinger. The absence of sparking is particularly notable, and shows that proper attention is being given to the sands.

In addition there are two large jar-ram roll-over machines by Pneulec. The bay is spanned by a 10-ton and two 5-ton Babcock & Wilcox electric travelling cranes, whilst the Sandslinger has a special gantry which carries two 1½-ton cranes operated from the floor.

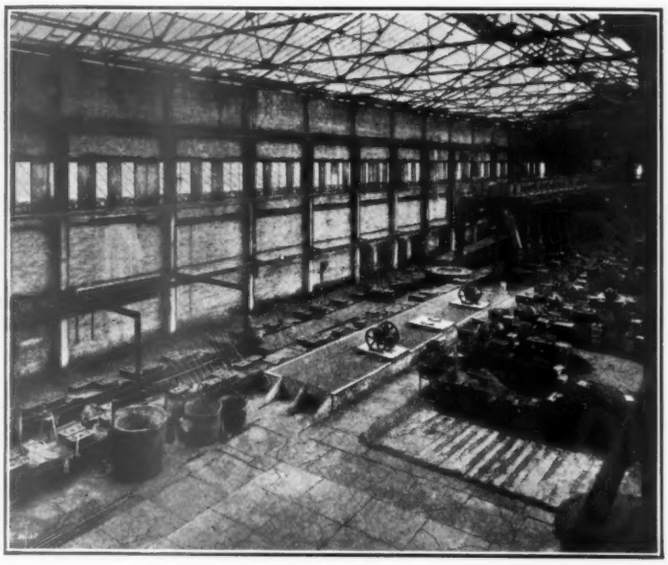

Fig. 8.—Continuous Casting Plant, showing Mould Conveyor.

The second bay is taken up by the storage bins, hand moulding floors and an August sand plant. The third bay is devoted to dry-sand moulding for the making of the heaviest castings. For this purpose there is a stationary Sandslinger and large jolt-rollover machines. At the further end there is the continuous casting plant and a battery of snap-flask moulding machines.

Fig. 9.—Sand Preparing Plant for the Mechanised Section.

The fourth bay includes a number of moulding floors, one of which is devoted to alloy cast irons, dressing, machining, packing and despatch.

Moulding

As previously stated, no reference is being made to the melting plant, beyond stating that there is a small cupola used for the melting of malleable iron, which was not dealt with in Mr. Braidwood's article. Hand moulding is confined to castings made in quite small quantities, where the cost of mounting patterns on a machine would not be justified. This involves the making of about 500 moulds per day by hand. The largest casting regularly made is a base plate for a pulverised coal plant; it measures 16 ft. long by 6 ft. 6 in. wide by 1 ft. 6 in. deep, and weighs about 5 tons. Various types of jar roll-over hydraulic squeezers and Sandslingers are used, and these together produce something of the order of 2,600 moulds per day.

Continuous Casting Plant

This plant has been designed and erected by Herbert Morris, Limited, of Loughborough, and is illustrated in Fig. 8. Its main production is stoker-link work. This permits of the use of boxless castings—a very considerable factor in the simplification of operation. By furnishing the outer edge of the mould conveyor plates with a flange and arranging for their tilting so as to discharge the cast-up mould on to an inclined apron conveyor, whilst the flange retains the bottom board, the knock-out problem becomes easy. The inclined apron conveyor discharges the sand and castings on to a bumping grating set at a declivity. Here two or three men fork the still-hot castings into stillages for removal to the fettling shop. The bottom boards used are perforated aluminium castings. An onerous problem has been at least partially solved by the installation between the legs of the mould conveyor of a manually-operated turntable, for the purpose of returning the weights from the cast-up moulds to those passing along to the pouring station. The sand plant incorporates the well-known barrel-like mill of Morris design, and it is interesting to note that it is not provided with knockers operated by fixing a cam on to the barrel. This indicates that the sand used is not excessively sticky, a matter confirmed by an examination of the hoppers over the moulding machines, which were free from indications of rapping. The nine moulding machines are of the hydraulic squeeze type, built by Babcock & Wilcox, and as the pattern-plates swing out between each operation they find themselves well up against an electric resistance heater. The

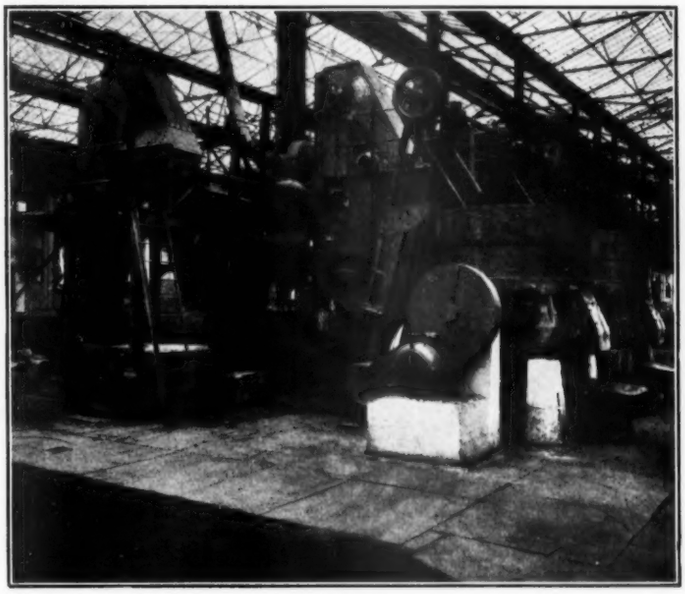

Fig. 10.—Facing-Sand Preparing Plant for the General Foundry.

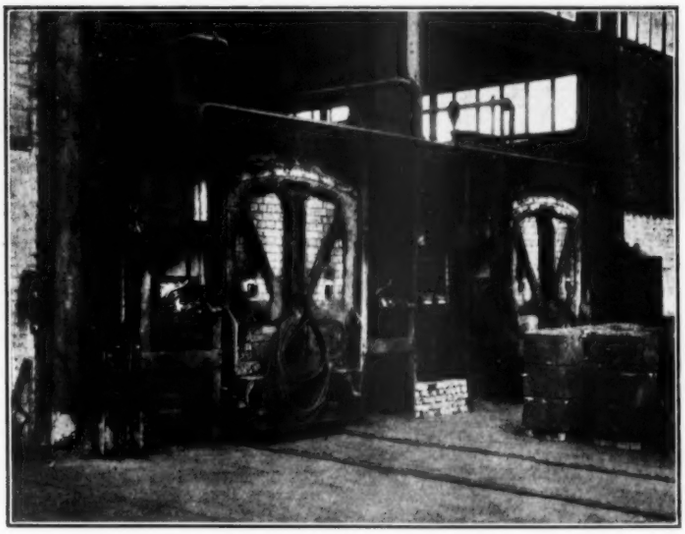

Fig. 11.—Malleablising Furnaces for the Production of Whiteheart.

moulding sand for this plant is reconditioned in the plant shown in Fig. 9, which handles about 30 tons per hr. The plant follows the general lines of installations made by Morris, several of which have been described in our columns, yet a full description of it got out on lines similar to those employed by Mr. Braidwood would make a useful contribution to the general question of continuous casting plants. The plant carries a staff of seven men and eight youths, and in a single shift makes between 5,500 and 6,000 moulds, or a matter of 40 tons of castings.

Fig. 12.—Core-making Department.

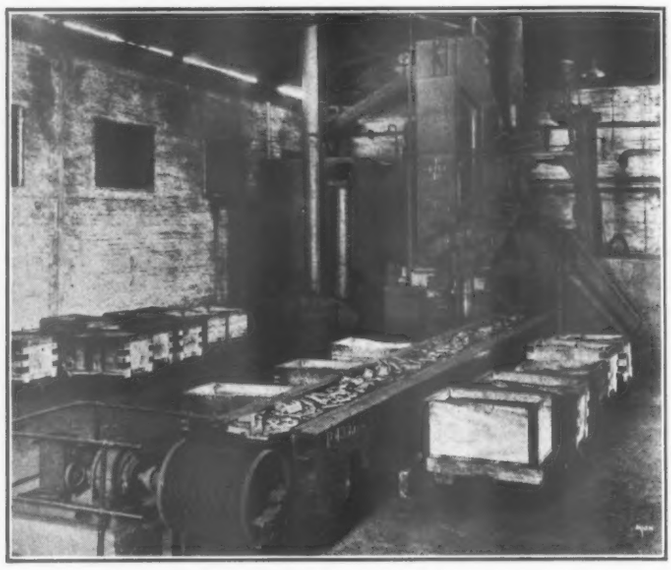

Fig. 14.—Shot-Slinging Machine and Sorting Conveyor.

Sand Preparation

The facing sand for castings not made on the continuous plant, which utilises a general-purpose mixture, is prepared in a completely self-contained unit designed and manufactured by August's, Limited. This double plant is illustrated in Fig. 10. Incorporated in the plant are an elevator, storage hopper, silt extractor, screen, magnetic separator and bucket loader, whilst each of the two pan mills has a disintegrator fitted into the discharge. The capacity of the plant is 5 tons per hr., and as it works continuously night and day, it reconditions about 60 tons of sand each double shift.

At the top end of the first bay are two tar oil-fired annealing furnaces for malleable castings, the plant being illustrated in Fig. 11. It handles a production of about 10 tons per week. The material made is of the whiteheart variety, and the cycle used is 1½ days in heating up to 1,000 deg. C., maintaining that temperature for three days, and then cooling down for a further 2½ days before discharging the contents. Superficially, criticism could be levelled against the relative locations of the annealing oven and the malleable moulding floor, but, recalling the fact that 100 tons of material have to be moved to make a ton of castings, the one movement of the hard castings across the shop is insignificant.

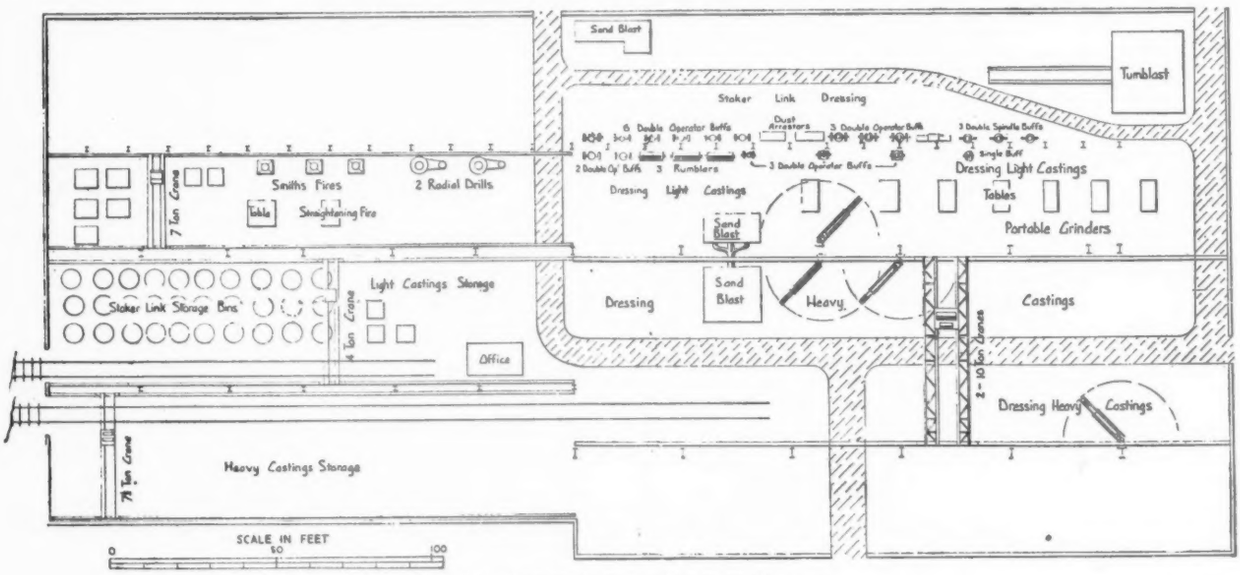

Fig. 13.—Lay-out of the Fettling Shop.

Core Making

The core shop, which is included in the general layout drawing of the foundry (Fig. 1 of Mr. Braidwood's article) represents a good example of straight-line production. Raw materials are received at one end of the section and the finished cores are taken from store at the other end for distribution throughout the foundry. Core sand is taken from its storage bin and passed through a Pneulec rotary drier to a cooling drum, whilst at the same time a suction fan removes the silt content and the silt-free sand is elevated to a hopper. Thence the sand is measured into a skip hoist, which discharges its contents into a mixing mill, also by Pneulec.

Here the oil and other ingredients are added, and after 7 mins. mixing the oil-sand mixture is discharged into service hoppers for distribution to the core benches.

The cores are made by girl labour within two paths of a roller conveyor. The general system is well illustrated in Fig. 12. The cores on their carrier plates are slid along the roller pathway to be dried in an Acme continuous core drying stove. This stove operates at a temperature of 230 deg. C. when using a 2¼-hr. cycle. The output of the 25 girls is of the order of 6,000 cores per day. This production is made possible because of the use of some Jackman jar-ram machines and a Coleman Revolver core blower.

Cleaning the Castings

The knocked-out castings are conveyed from the foundry by rail and by motor truck to a large and particularly well equipped dressing shop shown in Fig. 13. The larger castings are transferred to a shot-blast room and then to the fettling floors for finishing off. The smaller castings, such as stoker links made on the continuous plant, are cleaned in a Wheelabrator Tum-blast machine, which discharges its contents on a steel-mesh band conveyor. This plant is shown in Fig. 14. Alongside this, men are engaged sorting the various designs into 10-cwt. bogies. These bogies are then passed along to various types of grinding wheels into a straight line of production, the operations being in the following sequence: gauge; profile-buff; spindle-buff; side-buff and gauge. From here they are weighed and either stocked in bins or dispatched from the works. A stock of nearly 350,000 standard stoker-links is maintained in order to minimise delays in supplying replacement parts.

FIG. 15.—A CORNER OF THE SAND LABORATORY.

Technical Control

The high order of the technical control instituted in these foundries was well illustrated by Mr. Braidwood's article, and similar vigilance is exercised over the sand. A sand laboratory, a corner of which is shown in Fig. 15, has been installed. It is equipped with A.F.A. standard permeability apparatus and a Speedy moisture tester, in addition to the usual apparatus essential to sand control. The results, which are obtained several times during the day, are plainly posted up on blackboards in the foundries.

The foundry staff is indeed fortunate in having at its disposal a brilliantly organised and excellently equipped research department. It contains a full range of chemical, physical and micrographical departments, and a mechanical-testing laboratory. Extensive use is made of plastics in the mounting of micro-specimens, so that the edges of samples can be better examined, and a small press has been designed in the laboratory for this purpose. The calorimetry department is amongst the best the writer has so far inspected.

L.N.E.R. Orders

The L.N.E.R. has placed contracts for passenger coaches worth £1,500,000. The coaches are to be used on the lines now being electrified between Liverpool Street and Fenchurch Street and Shenfield and between Manchester and Glossop. Orders for coaches and equipment have been placed with the Metropolitan Cammell Carriage & Wagon Company, Limited, the Birmingham Railway Carriage & Wagon Company, Limited, the English Electric Company, Limited, and the General Electric Company, Limited.

Development in Magnetic Separation

During the past few years, revolutionary changes have taken place in the technique of permanent-magnet manufacture. While the permanent magnet lent itself peculiarly well to many industrial uses, its application to such duties was negatived by the fact that it lost power with age.

The evolution of a powerful magnetic alloy known as "Alnico" opens up new and important possibilities for the permanent magnet.

Valuable features of the alloy are that whilst it is less expensive than materials hitherto available, due to its low density, substantial reductions in weight of the apparatus are possible. With the particular alloy combined with the method of manufacture, the state of internal strain, in other words the magnetic power, can be maintained over practically unlimited periods of time.

Electromagnets, Limited, of Erdington, Birmingham, have acquired the sole rights from a Sheffield firm manufacturing "Alnico" magnet steel under licence, and have developed a complete range of magnetic separators and kindred equipments incorporating this new class of steel. Whilst the application of the permanent magnet has called for but slight modifications in the general design of the separators, the effects are, of course, very far-reaching.

The very nature of the duties of the magnetic separator invariably oblige its installation in positions which are not readily accessible. Its maintained efficiency and freedom from breakdown are thus factors of vital importance.

The use of a permanent magnet, of course, renders the separator independent of electrical supply with the attendant rectifiers and convertors. Wires, connections and other extraneous apparatus are dispensed with, the separator thus becomes entirely self-contained and is readily portable, providing power is available to drive the drum, or belt as the case may be; with the shute-types no power is, of course, required.

The collapsible bridge, which is an integral part of the shute-type separator using electrical magnets, to provide against a failure of current from any untoward cause, is unnecessary with the permanent magnet, the only possible form of failure being mechanical, *i.e.*, the drive to where drum and pulley separators are used. In the event of such failure it will be obvious the tramp iron would be held by all types incorporating permanent magnets and could not pass over into the separated material.

Iron and Steel Institute

ANNUAL MEETING, 1939

The annual meeting of the Iron and Steel Institute will take place, by kind permission, in the Lecture Theatre of the Institution of Civil Engineers, Great George Street, Westminster, S.W.1, on Wednesday, Thursday and Friday, May 3, 4 and 5, 1939.

Programme of Proceedings

WEDNESDAY, MAY 3.

10 a.m.—*Morning Session.* Presentation of annual report and statement of accounts for 1938; election of new members and associates; presentation of the Bessemer Gold Medal for 1939 to Mr. James Henderson.

Discussion on the Eighth Report on the Heterogeneity of Steel Ingots.

2.30 p.m.—*Afternoon Session.* Presentation of Paper No. 6 and further discussion on Eighth Report on the Heterogeneity of Steel Ingots.

THURSDAY, MAY 4.

10 a.m.—*Morning Session.* Presentation of Papers Nos. 5, 8, 1 and 7.

2.30 p.m.—*Afternoon Session.* Presentation of Papers No. 3 and "First Report on Refractory Materials."

FRIDAY, MAY 5.

10 a.m.—*Morning Session.* Presentation of Second Report of the Alloy Steels Research Committee.

List of Papers

No. 1.—F. G. BARKER: "Some Applications of the Spectrograph to the Quantitative Analysis of Ferrous and Non-Ferrous Metals."

No. 2.—W. BETTERIDGE: "Nickel-Iron-Aluminium Permanent Magnet Alloys."

No. 3.—H. E. BLAYDEN, W. NOBLE and H. L. RILEY: "The Influence of Carbonising Conditions on Coke Properties. Part II.—The Effect of Pressure, Temperature, Rate of Heating and 'Soaking' on Coke Strength."

No. 4.—E. W. COLBECK and R. P. GARNER: "The Effect of Nitrogen Additions and Heat Treatment on the Properties of High-Chromium Steels."

No. 5.—C. A. EDWARDS, F.R.S., N. H. JONES and B. WALTERS: "A Study of 'Strain-Age-Hardening' of Mild Steel."

No. 6.—W. B. LAWRIE: "The Refining of Metal in the Basic Open-Hearth Furnace. The Influence of Fluorspar on the Process."

No. 7.—L. NORTHCOTT: "The Application of the Durville Rotatory Process to the Casting of Steel."

No. 8.—J. W. RODGERS and H. A. WAINWRIGHT: "The Strain-Ageing of Dead-Mild Steel Strip Used in the Pressing of Automobile Bodies and Accessories."

No. 9.—W. J. REES: "Note on the Slow Cooling of Ingots."

No. 10.—T. F. RUSSELL: "Interpretation of Thermal Curves and some Applications to Ferrous Alloys."

No. 11.—HAAKON STYRI: "Slag Inclusions and Acid Open-Hearth Refining of High-Carbon Steel."

No. 12.—C. SYKES and F. W. JONES: "Note on Discontinuities in the Resistance-Temperature Curves of Commercially Pure Iron and Steel."

No. 13.—T. WILSON: "The Rolling of Sections at the Appleby-Frodingham Steel Company, Limited."

Ablett Prize Paper.—H. ESCHER: "Ten Years' Development in Steam Engineering at the Port Kembla Steelworks, N.S.W., Australia."

Annual Dinner

The annual dinner will be held at Grosvenor House, Park Lane, London, W.1, on Thursday, May 4, at 7 for 7.30 p.m., under the presidency of the Rt. Hon. the Earl of Dudley. Admiral of the Fleet, the Rt. Hon. Lord Chatfield, M.C., G.C.B., K.C.M.G., G.V.O., Minister for the Co-ordination of Defence, will be the guest of honour.

Molybdenum in Cast Iron*

By W. F. CHUBB, Ph.D., B.Sc.

As will probably be known, the adoption of molybdenum as an alloying addition to cast iron has been more general in America than in England, and this has sometimes been ascribed to a too conservative attitude on the part of British foundries. It is hoped, however, to show that this statement is in a large measure unjustified. Before a prospective user can be asked to adopt a new suggestion, it is necessary to satisfy him that not only are there definite benefits to be obtained, but that these benefits can be secured at a price which he can afford. Also, he must be convinced that, unless he is willing to pay the price, he cannot hope to derive the same benefits by other and cheaper means. It is thus the purpose of this lecture to attempt to determine how far molybdenum will meet and satisfy the demands of the up-to-date foundry and of modern engineering design.

There are several methods of attack for a lecture such as this. One could trace out the history of molybdenum in cast iron, showing the development of the subject and describing in detail the major and minor researches which have been undertaken. This does not, however, appear to be the best procedure, for the evidence and results of research are somewhat conflicting, and for this reason a very imperfect conception of the benefits which molybdenum can bring would be obtained. Instead, it is proposed to deal with the subject in a more general way and confine attention chiefly to tendencies. This treatment of the subject, it is hoped, will have several advantages, namely, that it will give all the most essential facts, deprived of unnecessary detail; the main facts are likely to be more easily grasped, and on that account more capable of immediate application, and, finally, future lines of development will perhaps be more readily apparent.

TABLE I.—*Forms of Molybdenum.*

Form.	Typical Analysis.	Remarks.
Ferro-Molybdenum (Lump or powder)	Per cent. Mo .. 72.02 Si .. 0.65 S .. 0.046 P .. 0.020 C .. 0.039 As .. 0.008 Mn .. 0.011 Cu .. 0.34	
Calcium Molybdate (Powder)	Per cent. Mo .. 42.47 SiO_2 .. 5.75 Fe_2O_3 .. 3.70 Al_2O_3 .. 2.20 CaO .. 19.00 S .. 0.04 P .. 0.02 (MoO_3 equivalent to 63.7 per cent.)	Varies, *e.g.*, Mo 46 per cent.
Molyte (lump) ..	Per cent. Mo .. 43.50 SiO_2 .. 39.80 Fe_2O_3 .. 4.94 Al_2O_3 .. 3.00 MnO .. 0.08 CaO .. 6.80 S .. 0.05 P .. 0.02 C .. 0.05	Varies, *e.g.*, Mo 47.75 per cent.
Molybdenum metal (powder)	(*a*) Mo .. 95 to 97 per cent. (*b*) Mo .. 99 per cent. Min.	

* Paper read before the London Branch of the Institute of British Foundrymen, Mr. C. C. Booth, J.P., presiding.

Forms of Molybdenum

In Table I are detailed the several forms in which molybdenum is available, and of these the pure metal is quite unsuitable for direct addition to cast iron. The analysis given in each instance may be taken as representative of the material, and little comment need be made at this stage beyond saying that ferro-molybdenum, calcium molybdate and molyte satisfy many requirements as addition agents.

Adding Molybdenum to Cast Iron

In the cupola, high recoveries are only possible when the cupola is reserved solely for producing molybdenum irons. If more than one type of iron is being made, then it is recommended that those castings required to contain molybdenum should be made from the first few tappings. Both ferro-molybdenum and calcium molybdate can be used in the cupola, the latter being added with each charge of coke and preferably by adding it as briquettes in order to avoid loss due to the formation of dust.

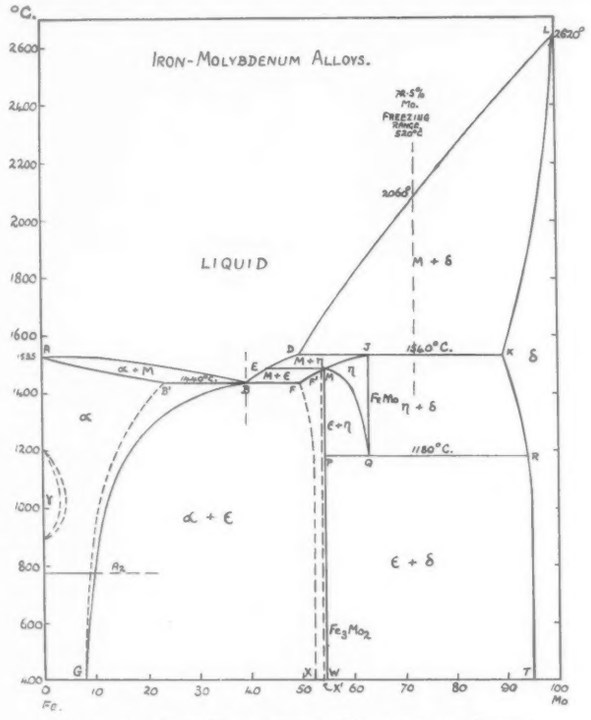

FIG. 1.—IRON-MOLYBDENUM EQUILIBRIUM SYSTEM.

Ferro-molybdenum is usually added to the spout or ladle, but when calcium molybdate is added in this way, time is necessary for reduction to molybdenum metal to take place at the lower temperature there prevailing. The recovery of molybdenum when calcium molybdate is added to the ladle is not as high as when it is added to the charge. Ferro-molybdenum of the composition given in Table I is likely to give non-uniform irons if added to the ladle, but this can be partly corrected by adding it to the charge, although recovery of molybdenum is then almost certain to be lower. For the air furnace, calcium molybdate and molyte can be added, but complete reduction to metal requires time. In the electric-furnace method of producing cast iron, both ferro-molybdenum and calcium molybdate are permissible.

For ladle additions, undoubtedly the best agent for adding molybdenum would be a molybdenum-iron alloy of low melting point, and having a melting point considerably lower than that of 70 per cent. ferro-molybdenum, the melting range of which is 1,540 to 2,060 deg. C., as shown in Fig. 1. A lower melting point can be obtained in several ways, namely, by the use of high carbon contents, high silicon, or by reducing the molybdenum content to 40 per cent. It will be seen that, at the latter composition, the melting point is 1,440 deg. C., and that the alloy melts at constant temperature. It would therefore appear that the ferro-molybdenum now available is not necessarily the best means of adding molybdenum to cast iron, especially when it is necessary to obtain rapid alloying and mixing of the constituent metals.

Molybdenum Pig-Iron

There is a growing tendency for users to adopt molybdenum pig-iron in preference to the other forms of molybdenum, as in that form it is perhaps the best means of adding molybdenum to cast iron, for cupola losses are then very much lower and the metal is more uniformly alloyed in the iron. There are two grades of molybdenum pig-iron available:—(1) T.C, 3.0 per cent. max.; Si, 1.5 to 2.0; Mn, 0.8 to 1.0; S, 0.07 max.; P, as required; and Mo, 1.0 to 5.0 per cent. This is a refined molybdenum pig-iron available as sand-cast or machine-cast pigs. (2) T.C, 3.5 per cent. max.; Si, 1.5 to 2.0; Mn, 0.8 to 1.0; S, 0.07 max.; P, as required; and Mo, 1.0 to 5.0 per cent. This is refined all-mine molybdenum pig-iron.

In addition there are other pig-irons available for the simultaneous addition of molybdenum and other alloying elements, but there would be no point in giving specifications, as they are almost invariably manufactured for individual requirements.

Metallographic Aspects

The metallographic influence of molybdenum on iron-carbon alloys may be summarised as follows:—

(1) The eutectic temperature is approximately the same as in pure iron-carbon alloys, namely, 1,130 deg. C.

(2) The percentage of carbon in the eutectic is not altered appreciably (4.3 per cent. carbon).

(3) The eutectoid transformation (*i.e.*, pearlite transformation) is not appreciably affected at 700 deg. C.

(4) The percentage of carbon in the eutectoid is lowered by molybdenum, the decrease being 20 points for each 1 per cent. of molybdenum present.

(5) A new phase appears, this being a double carbide above and below the eutectoid transformation.

(6) No graphite appears in iron-carbon-molybdenum alloys at carbon contents below the eutectoid concentration.

Translated into more practical language, this means that:—

(1) The melting point of cast iron is not lowered appreciably by molybdenum.

(2) The formation of a double carbide of iron and molybdenum is important as regards heat-treatment and physical properties, such as hardness and wear-resistance, and depth of hardening.

(3) The influence on the eutectoid composition is translated into more pronounced hardening on quenching, and in other directions also.

(4) Molybdenum tends to stabilise the carbides and therefore tends to prevent graphitisation.

(5) Molybdenum tends to remove hardness differences in castings of varying section.

Practical Points

This metal has a tendency to render cast iron sluggish, although experiences differ considerably. For this reason somewhat larger risers may possibly be required. These are also likely to be necessary because liquid shrinkage is increased to a certain extent, although here again experiences differ. Molybdenum also has a tendency to increase chill, and to counteract this many users take steps to keep the total carbon content as low as possible, thus producing irons of more uniform mechanical properties. These chilling tendencies are not, however, important in most instances, for, speaking quite generally, molybdenum is nearly always subordinate as an alloying addition to some other metal, such as nickel or chromium, or both. For higher percentages of molybdenum, namely, over 1 per cent., difficulty may possibly be encountered from chill, but in the amounts normally added to cast irons, little change in moulding and casting arrangements need be made, except in so far as are designed to meet special circumstances. Much appears to depend upon local conditions, so that it is not possible to give any very hard and fast rules, and the best procedure is that of determining those changes, if any, required by practical research in the foundry.

Simple Molybdenum Additions

It was Campion who first showed that 1 per cent. of molybdenum would increase strength and hardness, and Smalley in 1922 (*i.e.*, three years later than Campion) indicated that 0.1 per cent. of molybdenum has a refining action on the grain with only a slight increase in hardness. These results led to the suggestion that molybdenum might play the dual rôle of nickel and chromium, and it will be seen later how far molybdenum has come up to expectations. Among other men whose work in this field is of first importance, mention may be made of Piwowarsky, Smith and Aufderhaar, Kent Smith, Lorig and Dahle, Guillet and Ballay, Coyle, Hurst, Olsen, Cournot, Challansonnet, Portevin, McDougall and Schuck. Although many of their results are conflicting, there are, nevertheless, certain points of agreement, so that, considering the published data as a whole, the following general conclusions appear justified:—

(1) Molybdenum has a refining action on the graphite.

(2) There is a progressive increase in tensile strength up to 1.5 per cent. of molybdenum, and there is an increase also in both compressive strength and hardness.

(3) Transverse strength increases progressively with molybdenum content, although, when other alloying elements are present also, the influence of molybdenum is sometimes lessened. This will be rendered more clear by reference to the summarised properties to be illustrated later.

(4) Shock resistance is generally improved and about 0.5 per cent. of molybdenum has been known to treble the Izod figure, although the increase is generally about double. In any particular grade of iron, however, there is clearly a limit in the improvement to be obtained, and further additions beyond that limit result in carbide formation which interferes. The improvements to be obtained by small amounts of molybdenum are derived mainly from its grain-refining tendency and from its influence on the size and distribution of the graphite flakes. Later this toughening tendency is opposed by the hardening tendency of carbide formation.

(5) While machinability may be improved up to 0.5 per cent., the increases in hardness which result thereafter cause a progressive decrease in machinability. These decreases become more rapid above 1.5 per cent. of molybdenum, and they are, of course, associated with the carbide-forming tendencies of this element.

(6) Growth characteristics are not appreciably affected when molybdenum is added in small amounts.

(7) Molybdenum does not show any tendency of itself to improve resistance to scaling, neither does it have any appreciable influence on resistance to corrosion.

(8) Molybdenum has no desulphurising tendency despite its high affinity for sulphur. It combines preferentially with the carbon present, and any benefit so far as sulphur is concerned is derived from the fact that molybdenum causes the sulphides to disperse in a more finely divided condition throughout the material.

(9) Molybdenum affects structures by tending to convert the pearlite matrix into sorbitic pearlite, thus increasing strength, both tensile and transverse, and increasing toughness also. The benefits are approximately progressive up to 1.5 per cent. of molybdenum, but above this amount structures similar to those of hardened steels are beginning to form and hardness rapidly increases in consequence.

(10) Wear resistance is improved by molybdenum additions, although it does not appear possible to give a figure to represent the increase in life which may then be expected.

These ten points summarise the chief benefits to be obtained from the use of molybdenum alone in cast iron. It is necessary, however, to draw attention to one trouble likely to be experienced, and it is that molybdenum has been known to form brilliant spots locally in the iron, these being associated with the carbides to give local hardness. These brilliant spots will cause trouble in the machine shop, but while the exact conditions for their formation are not yet known, a practical remedy has been discovered, and nickel in small amounts has been found to counteract this trouble completely.

The benefits obtained from molybdenum alone may appear small in view of the cost. Thus, a 0.1 per cent. addition, with molybdenum at 4s. 9d. per lb., works out at about 11s. per ton of cast iron made. Many of the benefits are not, however, readily assessed in terms of cash, but these apparently high costs can be countered successfully by additions of certain other alloying elements, notably manganese, nickel and/or chromium, more particularly nickel.

Now, although molybdenum cast irons are not resistant to oxidising conditions, they maintain their original strength on short-time exposure to temperatures up to 425 deg. C. Creep rates for molybdenum cast irons are also lower than those of either grey iron or high-test cast iron at the same load and temperature. The indications are, in fact, that irons containing 0.8 to 1.0 per cent. of molybdenum will be serviceable at temperatures up to about 700 deg. C. and sometimes over, and these irons have in fact been used successfully under these conditions, since the rate of growth is reduced from 8 per cent. to less than 6 per cent. in tests of 24 hrs.' duration. Despite these very definite benefits, however, molybdenum irons suffer the disadvantage of not being resistant to oxidising conditions, and this fact is likely to limit their applications in high-temperature service.

Heat-Treatment

It may be stated as a fairly well-recognised rule that if the full benefit is to be obtained from the use of an expensive alloy addition the iron so made should be capable of heat-treatment to give further improvements in properties. Molybdenum irons are indeed capable of improvement in regard to tensile strength, transverse strength, toughness and hardness by suitable heat-treatment, and this fact must be taken into consideration in assessing its value as an alloying addition to cast iron. In plain molybdenum irons it is necessary to add a fair proportion of molybdenum, seldom less than about 0.5 per cent., if substantial improvements in properties are to be sought by heat-treatment. In order to illustrate the degree of improvement which can, however, be obtained, mention may be made of an iron containing T.C, 3.50; Mn, 0.5; Si, 1.6, and Mo, 0.6 to 0.7 per cent. As cast, this iron has a tensile strength of 19 to 20 tons per sq. in. with a Brinell hardness of 220 to 225, but after heat-treatment by quenching at 850 deg. C. and tempering at 350 deg. C., the tensile strength is improved to 30 tons per sq. in., that is, by about 50 per cent., and the Brinell hardness increased to 350, that is, by nearly 60 per cent.

Nickel-Molybdenum Irons

It is inevitable that chief interest must centre around the nickel-molybdenum irons, although they cannot here be treated exhaustively. The development of the nickel-molybdenum cast irons has resulted from the fact that, while the plain molybdenum cast irons can give many of the properties, or combinations of properties, required by producers and users, the amount of molybdenum necessary is such as to render its use prohibitive in a large number of instances. The price of nickel is about one-third that of molybdenum, and it will thus be realised that three times the amount of nickel can be used without increase in total alloy costs. Hence, if it be found that 0.5 per cent. of molybdenum will give the properties demanded, one can, as an alternative, use 1.5 per cent. of nickel, at a cost of about 53s. per ton of iron produced. It is open to question whether heat-treating a 0.5 per cent. molybdenum iron will give properties and benefits comparable with those to be obtained from that nickel cast iron which is of equal alloy cost. However, this difficulty can be surmounted by combining the two elements in appropriate proportions and, indeed, further progress can be registered, for those combinations of the two elements which give the same total cost will give also properties definitely superior to the properties obtainable from either the nickel or the molybdenum when added alone.

It will be realised that in these irons the molybdenum must be regarded as subordinate to the nickel, and it is convenient, in fact, to regard molybdenum as intensifying the benefits of the nickel. These benefits are, as is known, towards increased strength, toughness, resistance to shock, more uniform distribution of the graphite, more uniform hardness, greater hardening power and greater depth of hardening. Molybdenum adds to most of these benefits, but at a certain cost as previously shown, so that from both technical and commercial reasoning there is a limit to the amount of molybdenum which can be added profitably to nickel cast irons.

It will also be clear that if the nickel is increased and the molybdenum reduced, the total cost need not necessarily be increased, but the properties obtainable both as-cast and after heat-treatment can be varied over wide limits. These

facts are summarised in Table II. This table has been worked out assuming 100 per cent. recovery of the added element in each instance, but a practically theoretical recovery is only obtained in the case of nickel. Thus, the cost of losses in melting, alloying and casting, etc., must be added to the costs shown.

This table summarises the present position, and it shows also that the nickel-molybdenum irons of greatest practical utility having regard always

Table II.—*Alloying Costs.*

(Minimum increases per ton of iron, assuming 100 per cent. recovery of each metal.)

Composition.		Total alloy content.	Costs.		Total cost of alloys.	Cost per 1 per cent. of total alloys.
Ni. Per cent.	Mo. Per cent.	Per cent.	Ni. Per cent.	Mo. Per cent.		
3.0	1.0	4.0	102/6	105/6	209/–	52/3
2.5	0.8	3.3	94/–	85/6	179/6	54/5
2.0	0.7	2.7	75/–	74/6	149/6	55/6
1.5	0.0—0.15	1.5—1.65	56/–	0 to 16/–	56—72/–	37—43/8
1.0	0.35	1.35	38/–	37/–	75/–	55/6
0.5	0.5	1.0	19/–	53/–	72/–	72/–
0.35	1.0	1.35	13/–	107/–	120/–	89/–
0.0	1.5	1.5	—	160/–	160/–	106/8

Note.—To these costs must be added that of the metals lost during alloying on the basis of over 99 per cent. nickel recovery, and 92 to 96 per cent. molybdenum recovery, depending upon the method of alloying adopted.

to cost are those containing approximately 0.5 to 1.5 per cent. and 0 to 0.5 per cent. of molybdenum. It is within these ranges that most benefit is obtained for the money expended, and these irons are therefore likely to be the most frequently chosen. This table, furthermore, shows that special properties can be obtained but at greatly increased cost, which, however, is often justified by the additional benefits brought by heat-treatment. It will also be clear that if the ratio of nickel to molybdenum departs to any extent from the 3 to 1 ratio, the total alloying costs are disproportionately increased. When this happens, however, there are certain benefits to be derived from the increased molybdenum content, and these are chiefly to be experienced as regards improved wear resistance, as may be instanced by the fact that irons of this type have been adopted by some motor-car manufacturers for brakedrums. Hence, these considerations may be summarised by saying that the simultaneous addition of nickel effectively helps in reducing costs to a minimum.

Properties

The properties of the nickel-molybdenum cast irons have been very widely studied from both the metallographic and practical standpoints. The general conclusions to be drawn from the researches undertaken are that molybdenum increases the hardness and power of hardening, but that when the nickel content exceeds 1 per cent., molybdenum does not have any very pronounced refining tendency. That responsibility is assumed by the nickel, and thus molybdenum has only a graphite-refining tendency when acting alone. Also, molybdenum aids nickel in its tendency to eliminate internal porosity, but while molybdenum is likely to bring local hardness, nickel additions effectively prevent this. Molybdenum is also claimed by some authorities to increase machinability in nickel cast irons, but according to others it decreases this property. Much appears to depend on the method of testing, and so, considering all the relevant facts, molybdenum may be stated to convey some benefit in this direction.

The nickel-molybdenum irons of most use contain nickel equivalent to either two or three times the molybdenum content, and irons are also available with equal nickel and molybdenum contents. Their chief uses are machine-tool beds, grey iron patterns, drier rolls for paper machinery, general machinery castings, and hot-water heaters. The compositions usually chosen for these applications are 0.75 to 1.5 per cent. of nickel with up to 0.35 per cent. of molybdenum. Two practical considerations may here be mentioned. It may sometimes be necessary to reduce the total carbon content to prevent the tendency to form chilled structures, and it may also be necessary to reduce the silicon content when the higher nickel percentages are adopted owing to the graphitising tendency of nickel.

The heat-treated nickel-molybdenum iron may contain up to 2 per cent. of nickel, with appropriate molybdenum additions designed to increase the depth of hardening. Very nearly the same results can, however, be obtained by chromium in place of molybdenum, and this substitution is likely to be advantageous on a cost basis. Shovel blades are made in this type of iron, plough points, and other components of farming machinery.

A good deal can also be claimed for nickel-molybdenum irons when used as drop-forging dies. These contain 0.6 to 2.5 per cent. of nickel and 0.6 to 0.8 per cent. of molybdenum. The 3 to 1 ratio is often here replaced by nickel and molybdenum in equal proportions, in order to secure greater surface hardness. All these irons are tough, as they should be for these purposes, but they are preferably only used when a small number of forgings is required. There are, nevertheless, instances on record where nickel-molybdenum cast-iron dies have compared favourably with steel as regards life; and it is, in fact, claimed that they are superior to steel in certain specific instances, such as dies for optical glass.

High-strength irons produced by heat-treatment, either by annealing white iron or by the more usual quenching and tempering treatments, are most frequently made in nickel-molybdenum cast irons. Sometimes chromium is added also. These irons may contain up to 2.75 per cent. of nickel, and molybdenum must be no higher than one-third the nickel content if the optimum properties are to be developed. There are many applications for irons of this type, for they range in tensile strength from 25 to 40 tons per sq. in., and to mention but a few of these applications their use as gas-burner parts, pneumatic cylinders, compressor valve-seats, gears and bottle moulds may be recalled, their great advantage being that, when in contact with heat, they are structurally stable.

Fig. 2, reproduced by courtesy of the Mond Nickel Company, shows a boiler feed pump in a casing of high-test nickel-molybdenum cast iron. This iron was made from 80 per cent. steel scrap to keep down the total carbon content, 5 per cent. returned scrap, and 15 per cent. selected pig, the analysis of this iron being:—T.C, 2.62; Si, 2.38; Ni, 1.25; and Mo, 0.5 per cent. A high tensile strength of 36.7 tons per sq. in. was obtained in this iron, and it will be observed that the 3 to 1 alloying ratio has been maintained to develop the best combination of mechanical properties.

This example belongs to the class of irons known as "Ni-Tensyl," which, on account of their high strength and other valuable properties, are capable of replacing more costly steels. These irons are also adaptable to both light and heavy sections.

Fig. 3, also reproduced by courtesy of the Mond Nickel Company, shows another example of nickel-molybdenum cast irons, the particular iron illustrated containing T.C, 2.9 to 3.1; Si, 1.8 to 2.1; Ni, 1.35 to 1.55, and Mo, 0.4 to 0.6 per cent. These cylinders are for the hydraulic operation of sluice valves and are 26 in. inside diameter and 6 ft. 6 in. long. The iron was cupola-melted, using an extra high coke-bed and quick melting to keep down the total carbon content as much as possible, and the properties obtained were up to 35 tons per sq. in. in tensile strength with a Brinell numeral of 265 to 285.

Chromium-Molybdenum Irons

Chromium increases the hardness of cast iron on account of its carbide-forming tendencies, but accompanying these hardness increases there is likely to be a certain loss of shock toughness, particularly when chromium contents begin to assume fairly large proportions. These harmful tendencies can be corrected in two ways: (1) by addition of molybdenum, which, although also a carbide former, here increases the toughness, or (2) by additions of nickel, which, while it may or may not decrease the hardness, has a beneficial influence as regards shock toughness. In view of these facts, chrome-molybdenum irons are used where surface hardness obtained by chilling is required, one such use being tappets, where a tough material with a hard-wearing end surface is particularly suited to service conditions.

In the United States considerable use has been made of chrome-molybdenum irons for cylinder

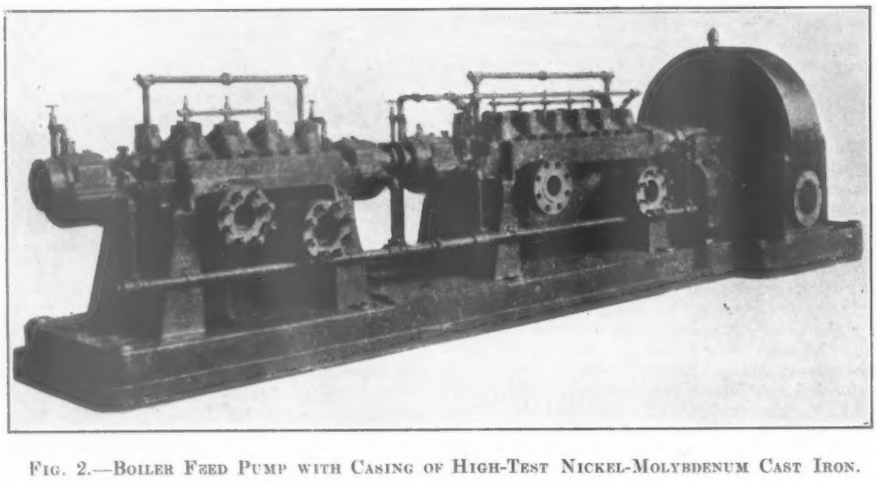

Fig. 2.—Boiler Feed Pump with Casing of High-Test Nickel-Molybdenum Cast Iron.

blocks and cylinder heads. These may contain up to 0.5 per cent. of chromium and a maximum of 0.4 per cent. of molybdenum, but other combinations have also been adopted with success. The influence of molybdenum on cylinder irons containing 0.5 per cent. of chromium has been examined carefully by a number of automobile manufacturers, and from the figures available the following average increases may be expected for every 0.1 per cent. of molybdenum added:—Tensile strength, 1 to 2 tons per sq. in.; transverse strength, 160 lbs.; Brinell hardness, 4 points, and resilience, 65 in.-lbs. These figures should be compared with those quoted for plain

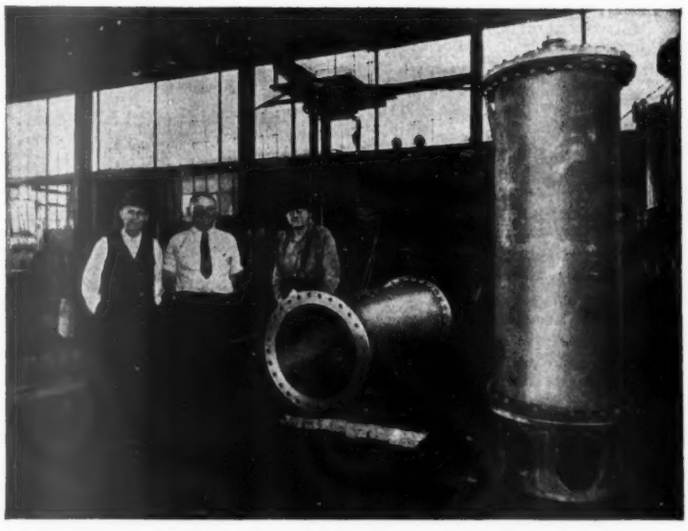

Fig. 3.—Cylinders for Sluice Valve Operation, cast in Nickel-Molybdenum Iron.

irons, when it will be seen that this combination of chromium and molybdenum is of special value where wear resistance is specially required.

Another widely-used chrome-molybdenum iron is that containing 0.35 per cent. chromium and an equal percentage of molybdenum. It gives a tensile strength of up to 22 tons per sq. in., transverse strength 2,700 to 3,200 lbs., deflection up to 0.300 in. and a Brinell hardness of 228 to 241.

The growth-resisting irons are not infrequently made from combinations of chromium and molybdenum, and they may contain up to 0.7 per cent. of chromium and up to 0.75 per cent. of molybdenum. Their selection is determined by their ability to resist surface oxidation, their ability to resist growth and changes of temperature, and their ability to maintain their strength and toughness at elevated temperatures. There are also cast irons suitable for this type of service in the nickel-molybdenum and nickel-chrome-molybdenum ranges.

Summary

An attempt has been made on the basis of the available data to show the trend of improvement likely to be obtained when molybdenum is added to various types of iron. Average figures obtained in this way are shown in Table III. These figures may possibly provoke discussion, because it is quite likely that entirely different results may have been obtained by individual users; but one fact is certain, and it is that the benefits to be derived from molybdenum additions to grey iron are not solely dependent upon molybdenum. This table illustrates this fact quite well, for it will be seen that the influence of molybdenum is dependent upon the type of other elements also added. Thus, the tendency to increases in hardness is least when chromium is present, and is greatest when nickel is present. This is due to the fact that, in chromium irons, molybdenum exerts a certain toughening action. The tendency towards increased transverse strength is greatest in the nickel-molybdenum combination, but the highest increases in tensile strength have been reported to occur in the chrome molybdenum cast irons. In the case of the nickel-chrome cast irons, it is difficult to assess the value of molybdenum in a similar way, and the average increases shown as regards transverse strength must be regarded as very approximate.

Possible Future Uses

It would not be a very difficult matter to compile a list of components which are now frequently made in molybdenum cast irons, nickel-molybdenum irons and nickel-chrome-molybdenum irons. It would be of no great value to emphasise the benefits of molybdenum for chilled rolls, for their use is now well established, and the reasons for choosing molybdenum cast irons for these applications are well understood. If progress, however, is to be made in the use of molybdenum cast irons, whether this element is used alone or in conjunction with other alloying metals, it is necessary first of all to grasp the essential facts concerning the possible benefits to be derived, and it is then necessary to seek out applications in which molybdenum is not being used and try to discover the reason or reasons why. In some instances the reasons are that the designer and manufacturer do not fully appreciate the value of molybdenum as an alloying element. Such men are rare, however, but it appears that the chief handicap of molybdenum is its price. Attempts have been made to show how this difficulty may be overcome to a greater or lesser extent by the simultaneous use of nickel, and it may thus be concluded that there are numerous applications where molybdenum is likely to prove of considerable advantage. Indeed, fifty applications come to mind immediately in which irons of this type could be usefully employed and in fairly large tonnage, and it is quite clear therefore that there is a big field available for exploitation.

Table III.—*Average Increases due to 0.1 Per Cent. Molybdenum.*

Combination.	Tensile strength. Tons per sq. in.	Transverse strength. Lbs. per sq. in.	Brinell hardness numeral.
Molybdenum alone ..	0.75	175	5
Molybdenum with nickel	1.0	400	12
Molybdenum with chromium ..	2.0	200	2
Molybdenum with nickel and chromium ..	0.75	200 (?)	3—4

Book Review

Pattern-Making for Engineers. By J. G. Horner. (Sixth edition. Revised and enlarged by Philip Gates.) Published by the Technical Press, Limited, 5, Ave Maria Lane, London, E.C.4. Price 15s. net.

The preface states that the authors have endeavoured to present a very important subject in a comprehensive and practical manner. After careful study of their work one feels repaid, and this thought is confirmed by the fact that a sixth and revised edition has been necessary. The book comprises 385 pages and 558 descriptive illustrations. A considerable number of the various types of pattern equipment is dealt with in detail, and the methods described and illustrated follow closely the generally proved and accepted practice.

The methods of construction used for the simple type of pattern equipment will be readily understood by the interested reader, but a certain amount of foundry experience will be necessary fully to appreciate the complicated construction used for the more intricate designs. The chapter dealing with patternshop equipment has been revised and now contains details of the design and application of a wide range of machines which are available for installation in the patternshop.

A study of this book is recommended to the student contemplating taking the Pattern-making or Foundry Practice Examinations conducted by the City and Guilds of London Institute, and indeed to anyone interested in pattern-making problems. No complete answer has yet been given to all these problems, but in this book the correct methods to be used to overcome a considerable number are explained. The title suggests the book has been prepared for the instruction of engineers, and if these individuals could be influenced, after a perusal of this publication, to order the construction of pattern equipment by the methods described, its purpose would be realised.

S. A. H.

Mould "Blowing"

Some experiments recently carried out in the foundry of a large motor-vehicle company have shown that it is now possible to "blow" moulds, much in the same way as cores are regularly "blown."

Briefly, what has been accomplished is to make ordinary clay-bonded moulding sand, wetted with its full measure of moisture, rise up some 6 or 7 ft. of vertical 1½-in. dia. steel pipe, then travel horizontally through a further 4 ft. of 1½-in. dia., 32 ft. of 1-in. dia. and, finally, through 21 ft. of 1-in. bore rubber hose, at the far end of which it is delivered, in a continuous stream, into moulding boxes. The filled moulding boxes do not require ramming, jolting or squeezing. The high speed at which the sand emerges after its journey through more than 60 ft. of pipe line produces a satisfactory mould, as hard as desired, and of correct permeability.

We expect very shortly to give detailed information of the process and of the results obtained with it. Meanwhile, it is of interest to know the system is of British origin, and it differs entirely from anything which has previously been done.

The Week's News in Brief

Trade Talk

BENNIS COMBUSTION, LIMITED, have been awarded the contract for the new boiler plant for the Portsmouth electricity power station.

SWAN, HUNTER AND WIGHAM RICHARDSON, LIMITED, of Wallsend, have received an order from the Postmaster-General for a cable-laying ship about 250 ft. long.

A TRAVELLING CRANE STOKER, weighing 100 tons, has been constructed by International Combustion, Limited, Derby, for the China Light Electric Power Company, Hong Kong.

TURNER & NEWALL, LIMITED, are providing at their twelve factories in the United Kingdom splinter and blast proof protection for all the employees. The total cost will be not less than £50,000.

TWO MORE blast furnaces are being started at the Cleveland Works, Grangetown, of Dorman, Long & Company, Limited. This will bring the number of furnaces working on the North-East Coast to 23.

THE OLD SHIPYARD of Wood, Skinner & Company, Limited, Pelaw, has been acquired by the National Shipbuilders' Security, Limited. It is understood that the site will be utilised for new industries after being cleared.

PRODUCTION at the new magnesium works to be established in Cardiff is expected to begin in the late summer of this year. The new works are to be run by International Alloys, Limited, whose present headquarters are at Slough.

HURST, NELSON & COMPANY, LIMITED, rolling stock manufacturers, Motherwell, have received a contract valued at £20,000 for ironwork from the Southern Railway of Argentina. The material will be used for the conversion of cattle wagons.

DOVER ENGINEERING WORKS, LIMITED, are erecting two Titan cupolas, with a melting capacity of two tons an hour, at the Dour Iron Foundry, Dover, as part of a reconstruction scheme. An electrically-operated automatic inclined charger, with hopper feed to both cupolas, is included in the installation.

THE CLIMAX MOLYBDENUM COMPANY OF EUROPE, LIMITED, has been established with offices at 2 and 3, Crosby Square, London, E.C.3. The company has been formed purely as a means of furthering the uses of molybdenum by the dissemination of technical information and co-operative research. Mr. W. F. Rowden is in charge of the activities.

THE JUBILEE of the Ironfounding Workers' Association was celebrated with a complimentary dinner to the foundation members in Falkirk on March 24. Mr. S. Glass (President) occupied the chair, and during the evening Mr. Robert Dawson (senior member of the executive council) presented wallets of notes to Mr. Hugh Murdoch (general secretary), ex-Provost Logan (treasurer) and Mr. Harry Sinclair (English organiser of the union).

A NEW iron and steel works, which incorporates a steel foundry capable of producing castings up to 5 tons, was officially opened on March 21 in Bulawayo, Southern Rhodesia, by the Governor of the Colony, Sir Herbert Stanley. The works cover thirty acres and will give employment to fifty Europeans and three hundred natives. In addition to the foundry, the plant includes an electric furnace, a 5-ton steam hammer, two rolling mills and a 15-cwt. drop stamp for the manufacture of forged steel balls.

Contracts Open

Abergavenny, April 10.—Provision and laying of 1,000 yds. of 4 in. dia., 8,000 yds. of 3 in. dia., and 1,200 yds. of 2 in. dia. cast-iron pipes, for the Rural District Council. Thomas & Morgan & Partners, engineers, 23, Gelliwastad Road, Pontypridd. (Fee £3 3s., returnable.)

Blackpool, April 12.—Cast-iron specials for the period ending March 30, 1940, for the Fylde Water Board. Mr. Geo. F. Atkinson, engineer to the Board, Sefton Street, Blackpool.

London, E.C., April 14.—Iron and steel; bolts, nuts, steam tubes; brass, iron, gunmetal and other castings, etc., for 12 months from June 1, for the Metropolitan Water Board. The Chief Engineer (Room 171), Offices of the Board, 173, Rosebery Avenue, London, E.C.1.

Personal

MR. LINDSAY KINNELL has changed his private address to Widdershins, Fairmile Lane, Cobham, Surrey.

MR. BEN HIRD has been appointed works manager to the Crown Foundry Company, Limited, Far Cotton, Northampton.

MR. JOSEPH WARD, chairman of Thos. W. Ward, Limited, is to receive the honorary degree of Doctor of Laws from Sheffield University.

MR. ARTHUR SMITH, a director of Izons & Company, Limited, hollow-ware manufacturers, West Bromwich, has been appointed a Justice of the Peace for the Borough of West Bromwich.

MR. J. LAWLEY, of West Bromwich, one of the family which founded the firm of W. & J. Lawley, Limited, ironfounders, and who, up to a few years ago, was the principal partner, has been appointed a Justice of the Peace for the Borough.

MR. J. N. BRADLEY, an assistant metallurgist in the L.M.S. research laboratory at Derby, has been awarded the Herbert Jackson prize for 1938. This prize is awarded annually by the company in memory of the late Sir Herbert Jackson, who was a member of the L.M.S. Advisory Committee on Scientific Research.

SHEFFIELD UNIVERSITY is to bestow the honorary degree of Doctor of Metallurgy on Mr. James Edgar Hurst, a past-President of the Institute of British Foundrymen and chairman of the International Commission for Testing Cast Iron. He is a former Editor of the FOUNDRY TRADE JOURNAL, and both an Oliver Stubbs and an E. J. Fox Gold Medallist.

MR. H. JAMES YATES, who has for twenty years been chairman and managing director of Radiation, Limited, is retiring. Mr. Yates amalgamated the Davis Gas Stove Company, John Wright & Eagle Range, Richmond Gas Stove Company, Fletcher Russell & Company, and Wilsons & Mathiesons, Limited, into an organisation now employing about 10,000 people. He has been connected with the foundry industry for 47 years.

Obituary

MR. CHARLES SHARDLOW, of St. Dunstans Road, Leicester, who claimed to be the oldest foundryman in the country, died last Friday, at the age of 88. At the time of his death he was manager of the Eclipse Foundry, Clarendon Street, Leicester, and he had been in the foundry trade for 76 years.

MR. H. C. WALKER, who died last Saturday at the age of 87, was a pioneer in the lift industry, having been associated with it for nearly 70 years when he retired from the chairmanship of Waygood-Otis, Limited, five years ago. He was also chairman of the Rodney Foundry Company, Limited.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Adaptable (Bearings), Limited.—Capital, £5,000. Manufacturers of ball, roller and other bearings. Directors: J. W. Gardom, 31, Wye Cliffe Road, Handsworth, Birmingham; A. C. Turner.

Metallurgical Reductions, Limited, 9, Clements Lane, London, E.C.4.—Capital, £25,000. To adopt an agreement with H. E. Coley and Abel Aide, Limited, and H. N. Wright, and to carry on the business of steelmakers and converters, etc. Directors: E. H. Allen, R. V. Cholmondley, H. E. Coley and H. N. Wright.

Meynell (B. P. Inventions), Limited, 18, Victoria Buildings, Deansgate, Manchester.—Capital, £1,000. To take over the business carried on at Manchester as "Henry Meynells Son & Company," and to carry on the business of machine brokers, ironfounders, manufacturers of textile machinery, etc.

Wallwork Gears, Limited, Roger Street, Red Bank, Manchester.—Capital, £35,000. To take over the business of engineers carried on (among other businesses not included in the sale) by Henry Wallwork & Company (1920), Limited, at Manchester. Director: A. V. Wallwork.

French Foundry Technical Association

ELECTION OF NEW OFFICERS

At the annual general meeting of the French Foundry Technical Association, held on March 14, in Paris, the following officers were elected:

President.—Mr. Jean Lobstein (Past-President of the French Foundry Proprietors' Federation and managing director of the Lobstein Works).

Senior Vice-President.—Mr. Pierre Chevenard (director of the Research Laboratories of the Commentry-Fourchambault-Decazeville concern and a Professor at the Paris Foundry High School).

Vice-Presidents.—Dr. Paul Bastien (Lecturer at the Ecole Centrale, and Supervisor at National Aeronautical College); Mr. J. Derdinger (Past-President of the French Brassfoundry Owners' Federation; lecturer at the Paris Foundry School, and a brass and bronze founder); Mr. C. Koehler (who holds office in several technical educational associations, and is general secretary of the French Foundry Proprietors' Federation and chairman of the St. Ouen Foundry Company); Mr. Roger Meyer (a partner in the Société de Produits Métallurgiques); Mr. Léon Montupet (managing director of the Montupet Foundry Company); Mr. A. Rousseau (President of the Foundry Mutual Benefit Society and manager of "Fonderie Moderne") and Mr. H. Strube (President of the Paris Foundry Employers' Federation, and engineer and founder).

Foreign Vice-Presidents.—Luxembourg, Mr. Léon Brasseur; Spain, Mr. J. M. España; Belgium, Mr. J. Léonard; Italy, Dr. Guido Vanzetti.

General Secretary.—Mr. Charles Dennery.

Treasurer.—Mr. D. Waeles (chairman of Apprentice Committee of the Paris Foundry Owners' Federation).

Company Reports

North British Locomotive Company, Limited.—Profit for 1938 of £63,137, which, deducted from the debit balance of £111,834 brought in, leaves £48,696 to be carried forward.

Watford Electric & Manufacturing Company, Limited.—Net profit for 1938, £24,886; brought in, £7,767; income-tax and N.D.C., £7,080; ordinary dividend of 15 per cent. for the year; carried forward, £14,573.

Associated Electrical Industries, Limited.—Profit for 1938, £1,399,499; depreciation, £229,934; income-tax and N.D.C., £124,498; special reserve, £100,000; dividend fund, £100,000; ordinary dividend of 10 per cent.

Parker, Winder & Achurch, Limited.—Profit for 1938, after writing off depreciation, providing for income-tax and N.D.C., £20,430; brought in, £10,753; dividend on the ordinary shares of 10 per cent.; to reserve, £10,000; carried forward, £14,353.

Federated Foundries, Limited.—Dividends declared by subsidiary companies for 1938, less income-tax and after providing for losses, £27,979; brought in, £20,779; dividend on the preference shares, £11,318; to goodwill reserve, £10,000; to additional depreciation reserve, £5,000; carried forward, £22,440.

Forthcoming Events

Institute of British Foundrymen

APRIL 3.

Lincolnshire Section:—Annual general meeting; short Papers and moulding competition, at Technical College, Lincoln, at 6.45 p.m.

APRIL 5.

London Branch:—Annual general meeting, and "Bronze Castings of Heavy Sections," Paper by A. Hopwood, at Charing Cross Hotel, London, at 8 p.m.

ROTALINE . . . this strong and durable refractory lining

. . . gives *longer life* in Rotary furnaces

Here is proof of the remarkable durability of Rotaline . . . this photograph, reproduced by the courtesy of L.M.S. Rly. Co., shows a Sesci furnace at their Crewe Works being tapped. This furnace, which is used for melting steel, is lined with Rotaline, and at the time the photograph was taken the furnace had completed 140 heats. The lining is still in good condition. Rotaline presents a strong, durable lining resistant to hard usage, while its low volume change obviates cracking and flaking of the lining.

GENERAL REFRACTORIES Ltd.

Telephone: *Sheffield* 31113 (6 *lines*). **GENEFAX HOUSE, SHEFFIELD, 10** *Telegrams:* "*Genefax, Sheffield.*"

Raw Material Markets

It cannot be said that the less satisfactory outlook in international affairs has made much difference to the condition of the iron market, especially in the high-phosphorus section, where consumers continue to buy only small tonnages to meet their immediate requirements. Hematite and low-phosphorus iron are both in quite good request in most districts, while the improved state of the steel market is maintained.

Pig-Iron

MIDDLESBROUGH.—The current production of Cleveland foundry iron is at a low ebb, but is sufficient to meet the demand. Consumers are not at all willing to enter into forward contracts and there has not been much business in small tonnages, as existing contracts in most instances are adequate to satisfy the needs of users. The export market continues to be very dull; owing to the low rates quoted by Continental producers, few orders are coming to hand. For deliveries in the Middlesbrough and Falkirk areas, No. 3 Cleveland G.M.B. foundry iron is quoted at 99s., No. 1 foundry 102s., and No. 4 foundry and No. 4 forge at 98s., less 5s. per ton rebate.

There has been a general improvement in the hematite section of the trade during the past month or two, and it would appear that the demand will continue to appreciate. No doubt, the higher rate of activity at the local steelworks has helped to bring about the change in the outlook, but most other consumers are also taking up larger tonnages. Makers' stocks are being steadily reduced, but it is not yet necessary to increase production. Business in the export section is limited to a few small tonnages. East Coast hematite mixed numbers are quoted at 120s. for delivery on the North-East Coast, 125s. 6d. in Sheffield, and 131s. in the Midlands.

LANCASHIRE.—Apart from the speciality engineers in this area, the demand for foundry iron remains on the quiet side. The textile-machinery makers and the light-castings founders continue to be employed very indifferently. Certain jobbing founders connected with the speciality engineers are quite well placed for orders, but others are still on short time. Thus, business is generally confined to small orders for early delivery and users are mostly refraining from buying ahead. The call for supplies of hematite is moderately satisfactory and the recent improvement in this section has been maintained, but producers would welcome a pronounced increase in business.

MIDLANDS.—Low-phosphorus iron and hematite are still the most satisfactory features of trade in this area and delivery specifications are on a good level, while new business is being transacted quite freely. The rearmament programme, of course, is using large tonnages of these grades of iron and is likely to continue to do so for a considerable time to come. A number of hematite consumers' contracts are due to expire shortly and there should then be a considerable amount of new buying. High-phosphorus iron is still in poor demand; apart from a few orders for small parcels, little has been done recently. It is hoped that business will improve in a few weeks' time, as it is expected that the light-castings foundries will be in a better position. For delivery to consumers in Birmingham and the Black Country, Derbyshire No. 3 foundry iron is quoted at 101s., with Northamptonshire No. 3 at 2s. 6d. per ton less, both subject to 5s. rebate.

SCOTLAND.—The tone of the foundry iron market here continues to be weak and buying is generally restricted to small tonnages. Many consumers, particularly among light-castings foundries, are working only intermittently and existing contracts are adequate to meet their requirements. No. 1 foundry iron is quoted at 108s., and No. 3 at 2s. 6d. less, f.o.t. furnaces. Business in Cleveland iron is negligible. Local steelworks are in a satisfactory position. Quotations for steel-making irons are as follow:—Hematite mixed numbers, 120s. 6d.; basic, 92s. 6d., both less 5s. rebate, delivered works.

Coke

Business in foundry coke continues to be satisfactory. Owing to a reduction in the demand on export and domestic accounts, some makers are having to put supplies into stock, but, on the whole, the trade is quite good. For delivery in Birmingham and district, the minimum price for both Durham and Welsh coke is 50s. 6d. per ton.

Steel

Owing to the international situation, business has been rather less active during the past few days, but this hesitancy is likely to be only of a temporary nature. The demand for structural steel continues to improve, although most producers are in a position to take on more work. Existing contracts in this section are being worked off at a better rate, while there has been a fair amount of new business. Most other sections of the trade are better placed for work, largely as a result of the Government's orders for rearmament. Air-raid shelters, especially, continue to involve the use of large tonnages of sheets.

Scrap

There continues to be a keen demand for most grades of iron and steel scrap and supplies of many descriptions are distinctly scarce. Heavy steel scrap is particularly well taken up by the steelworks and merchants are hard pressed to meet the call for supplies. Although nothing has been done yet, it is expected that there will shortly be some moves to import material in order to supplement home scrap supplies.

Metals

In view of the unsettled condition of European affairs, the tone on the London Metal Exchange has been remarkably steady. In fact, it would seem that non-ferrous metals have become inured to disturbing events in politics.

Copper.—While business is not exactly active at the present time, there has been a moderately good demand for this metal during the past week. Many consumers have specified freely against long-term contracts. The Metallgesellschaft announces that world copper production last year totalled 1,970,740 metric tons, as compared with 2,256,961 tons in 1937. World production in December, at 192,824 tons, was little changed compared with the previous month.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £42 17s. 6d. to £42 18s. 9d.; Friday, £43 to £43 1s. 3d.; Monday, £43 7s. 6d. to £43 8s. 9d.; Tuesday, £43 2s. 6d. to £43 5s.; Wednesday, £43 1s. 3d. to £43 2s. 6d.

Three Months.—Thursday, £43 2s. 6d. to £43 3s. 9d.; Friday, £43 5s. to £43 7s. 6d.; Monday, £43 12s. 6d. to £43 15s.; Tuesday, £43 8s. 9d. to £43 10s.; Wednesday, £43 6s. 3d. to £43 8s. 9d.

Tin.—At their meeting in London last week the International Tin Committee decided to reduce quotas for the second quarter of the year by 5 per cent. to 40 per cent. of standard tonnages. This decision caused little surprise to the market, and was as suggested in our last issue. Arrangements were also made for the liquidation of the existing over-exports. The next meeting of the Committee will be held at The Hague on April 27. The tone of the market has improved following the natural repercussions of the international situation.

The Statistical Bulletin of the International Tin Research and Development Council states that world tin production in January amounted to 15,900 tons, against 9,300 tons in the preceding month and 13,900 tons in January, 1938. World apparent tin consumption in January totalled 11,300 tons, against 11,300 tons in the preceding month and 13,900 tons in January, 1938, while world tinplate production in January amounted to nearly 270,000 tons, against 250,000 tons in December and 241,000 tons in January, 1938.

Official quotations were as follow :—

Cash.—Thursday, £215 to £215 5s.; Friday, £217 to £217 5s.; Monday, £217 to £217 5s.; Tuesday, £216 to £216 5s.; Wednesday, £215 15s. to £216 15s.

Three Months.—Thursday, £214 to £214 5s.; Friday, £215 5s. to £215 10s.; Monday, £215 15s. to £216; Tuesday, £214 15s. to £215; Wednesday, £214 10s. to £214 12s. 6d.

Spelter.—In the circumstances, the tone of this market has been quite firm, although consumers are naturally hesitant about placing orders for forward deliveries. The weekly market report issued by Rudolf Wolff & Company states that "business with consumers has been satisfactory and, generally speaking, consumption is well maintained. At the moment the market does not present any very definite tendency, for, on the one hand, the low price would reasonably seem to preclude the possibility of further decline, but, on the other hand, the political outlook is a consistently restricting influence."

Daily market prices :—

Ordinary. — Thursday, £13 15s.; Friday, £13 13s. 9d.; Monday, £13 13s. 9d.; Tuesday, £13 13s. 9d.; Wednesday, £13 12s. 6d.

Lead.—The undertone of the market continues to be quite sound, and consumption is reported to be well maintained. Business has been moderately satisfactory, although buyers are not interested in making long-term contracts, owing to the uncertainty of the forward position.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £14 15s.; Friday, £14 16s. 3d.; Monday, £14 16s. 3d.; Tuesday, £14 13s. 9d.; Wednesday, £14 11s. 3d.

Scrap.—As a result of the unsettled outlook, there has been rather less business about during the past week or so.

MACHINERY—*Continued from page 16*

SEMI-ROTARY FURNACES, fitted with two oil burners, also Whitemetal Valve Outlet Anti-Friction Melting Furnaces, Bale-Out and Lift-Out Crucible Furnaces, for Brass, Aluminium and Bronze Alloys, from Armstrong-Whitworth Stock.—MONARD, LTD., 115, Strand, London, W.C.2.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

MISCELLANEOUS

"A STUDY IN ECONOMY"
ACTUAL MANUFACTURES
BY USING OUR

Foundry Blackings, Facings, Parting Powder, Core Gum, Terra Flake, Talc Coal Dusts, Ganister, Ceylon Plumbago (Imports direct). We definitely help to produce perfect Castings. Only the best minerals used in the making. A trial order will convince users of their economic value.

JOHN & C. DURRANS,
PENNINE WORKS, HAZLEHEAD,
NEAR SHEFFIELD.

Telephone : 128 Penistone. Telegrams : Facings, Penistone.

R. J. RICHARDSON & SONS, LTD.
COMMERCIAL STREET, BIRMINGHAM, 1
Airless and Pressure Blast Cleaning Plants

AIR COMPRESSORS
DUST ARRESTERS
CHILLED IRON SHOT—BLASTYTE
FOUNDRY EQUIPMENT

WE SHOT OR SAND-BLAST FOR ALL TRADES

Telephone : MIDLAND 2281 & 2282.